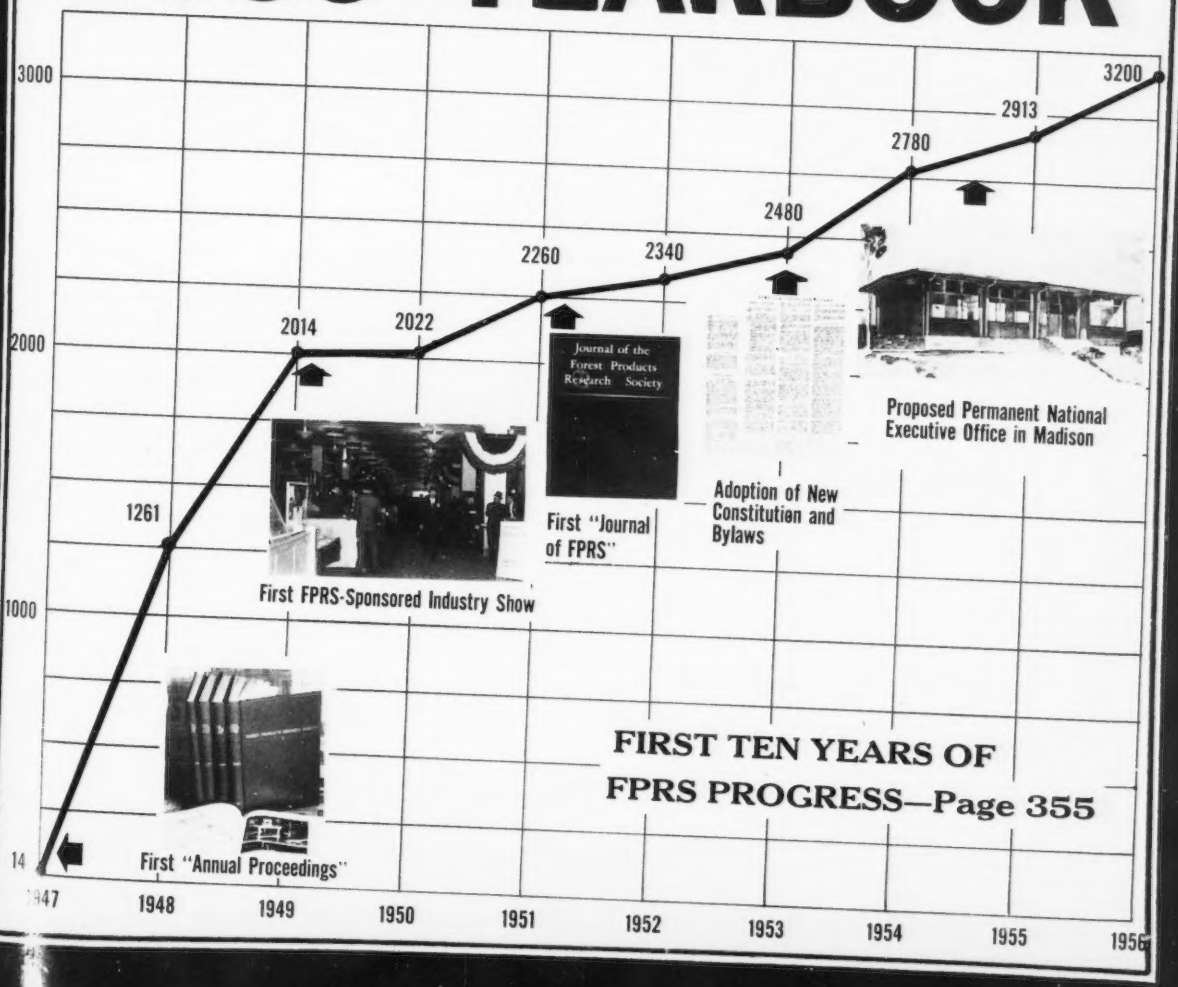
COMPLETE REPORT OF NATIONAL MEETING—p. 37-A

Forest Products Journal

Vol. VI, No. 10 October, 1956

1956 YEARBOOK



FIRST TEN YEARS OF FPRS PROGRESS—Page 355

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. . . for increased assembly time of glue-spread veneers

. . . for improved durability

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% CYMEL 401 (of Resin Solids)	Maximum Assembly Time (Hours)		Durability (Boil Resistance — Hours Without Delamination)	
	Unextended Formulation	Intermediate Flour-Extended Formulation	Unextended Formulation	Flour-Extended Formulation
0	less than 3	less than 3	less than ½	less than ½
5	12 — 15	10 — 12	1	1
10	15 — 20	20 — 24	2	2
15	20 — 24		3	
20	20 — 24		4	

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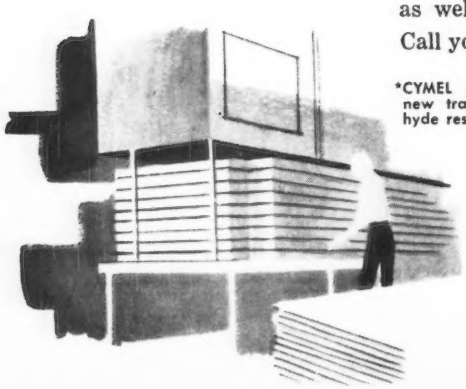

*CYMEL is American Cyanamid Company's new trademark for its melamine-formaldehyde resins.

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THE FOREST PRODUCTS JOURNAL is published monthly by the Forest Products Research Society, P. O. Box 2010, University Station, Madison 5, Wisconsin. Entered as Second-Class Matter, April 1952 at the Post Office, at Madison, Wisconsin.

Annual subscription rate, $15.00; single copies $1.00, except October Yearbook Number, $4.00. Annual subscription rate is $11.25 with voting, associate, and supporting memberships in the Society. Remittances should be made payable to the Forest Products Research Society.

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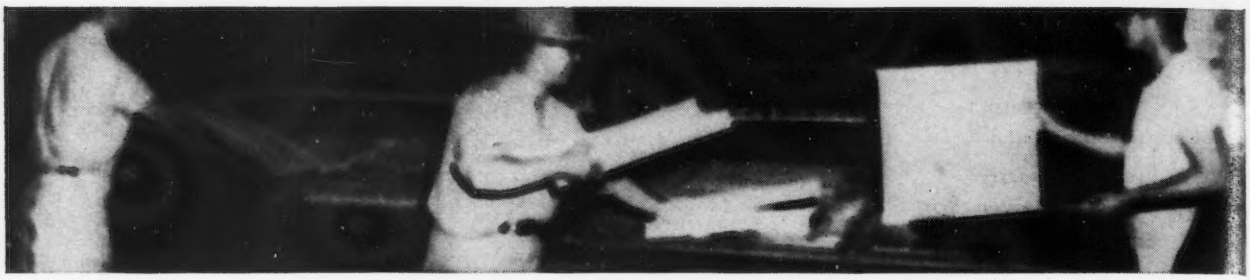

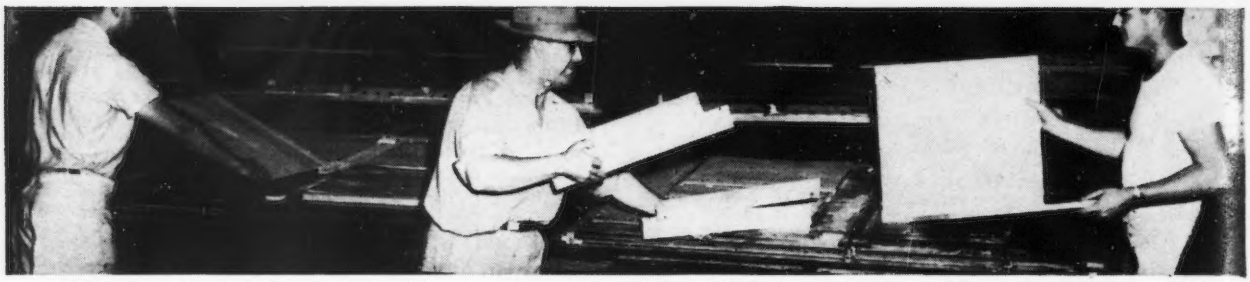

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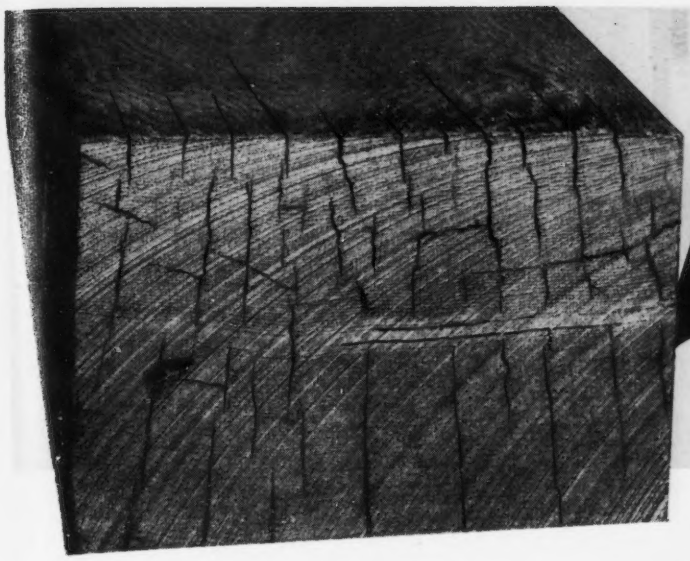

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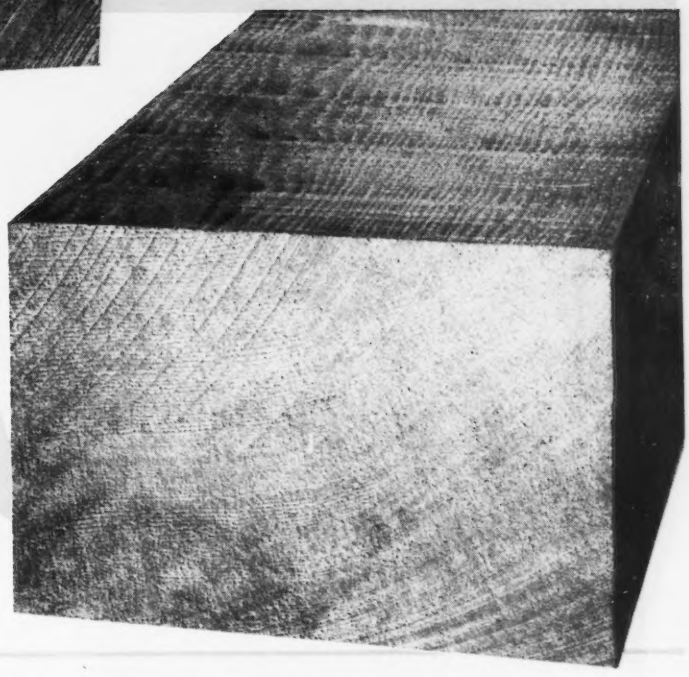

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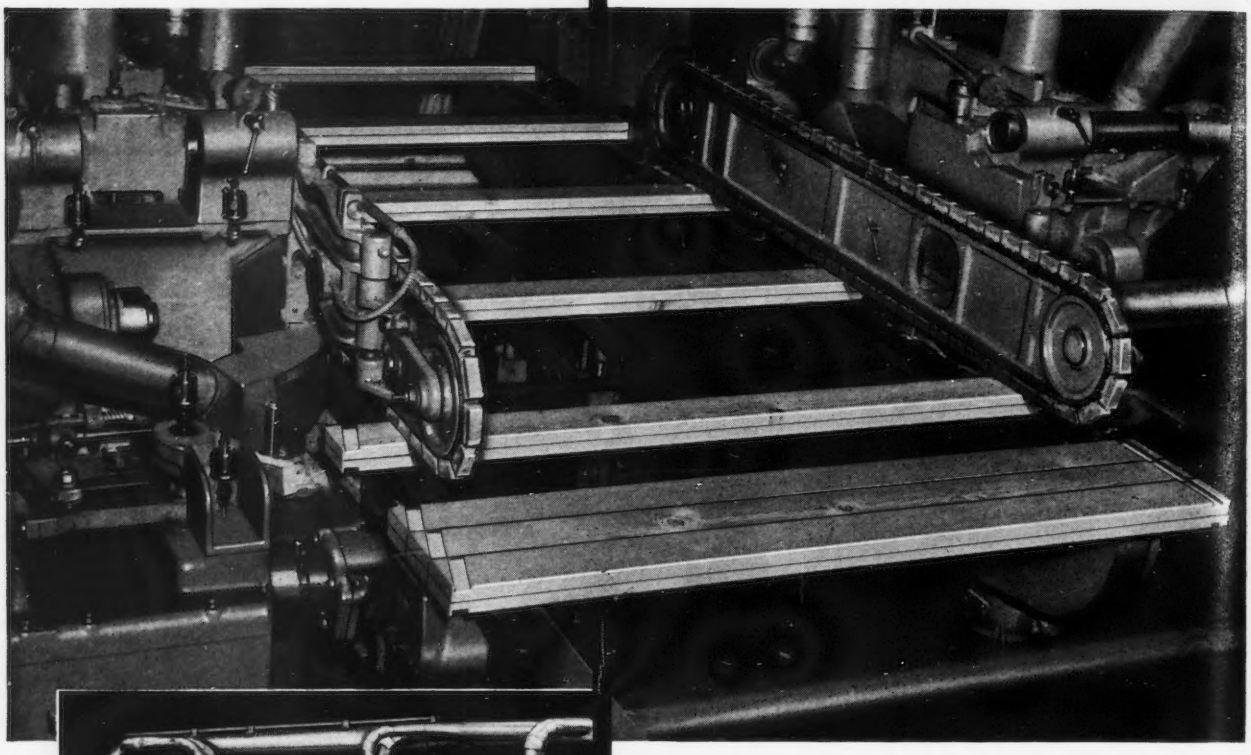

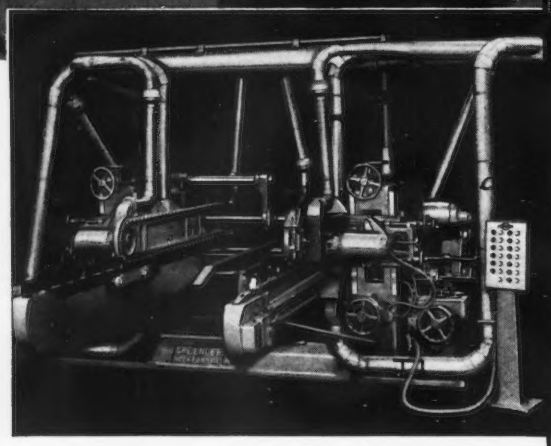

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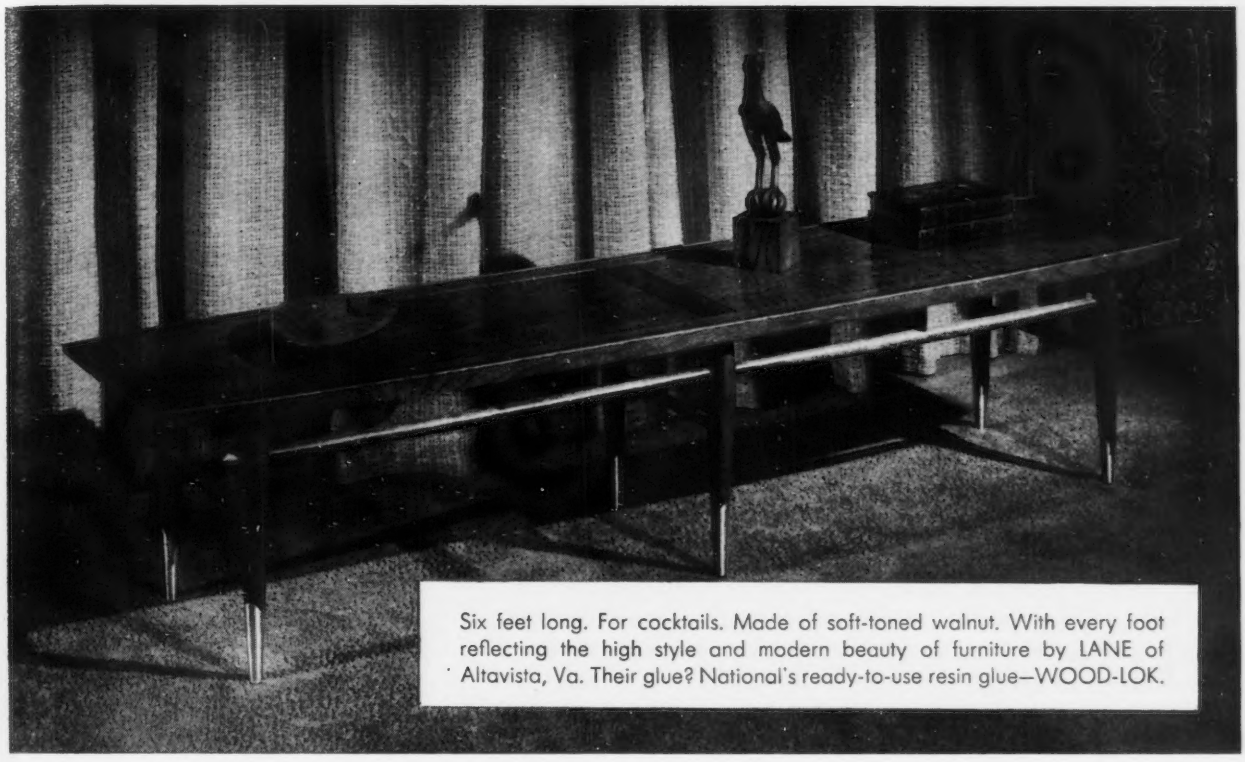

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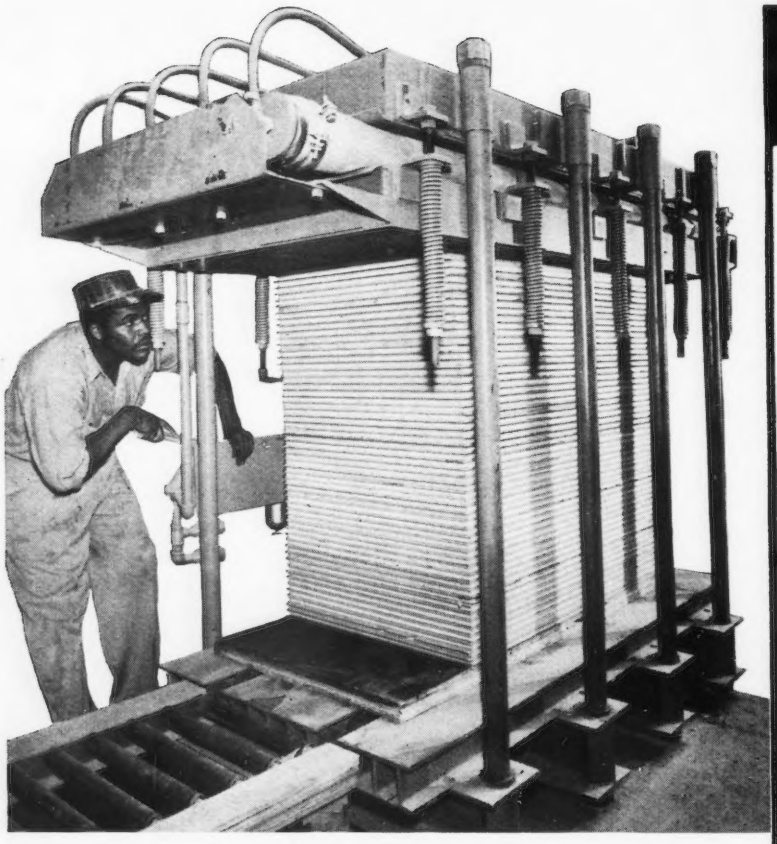

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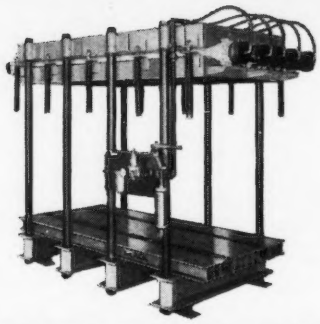

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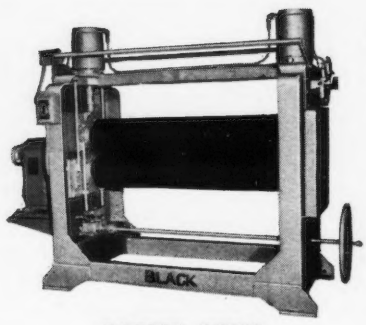

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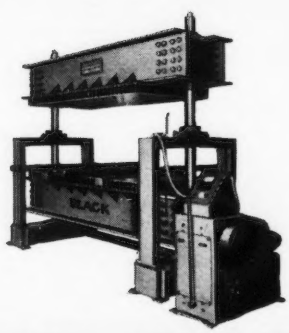

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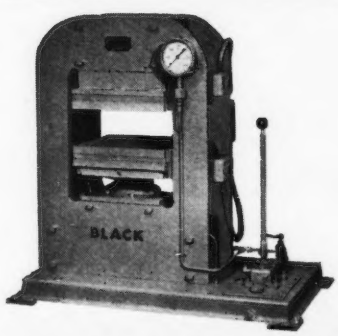

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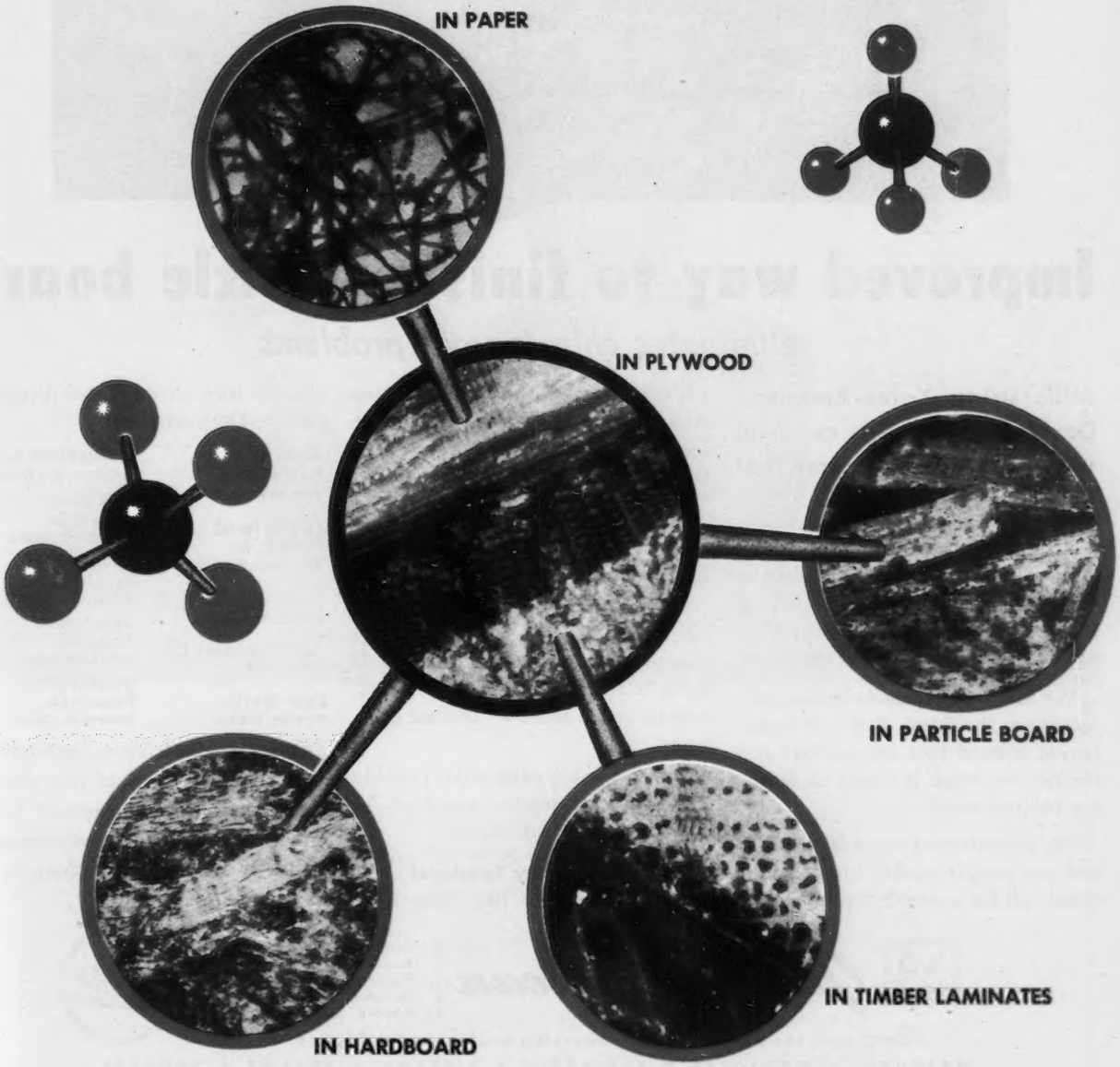

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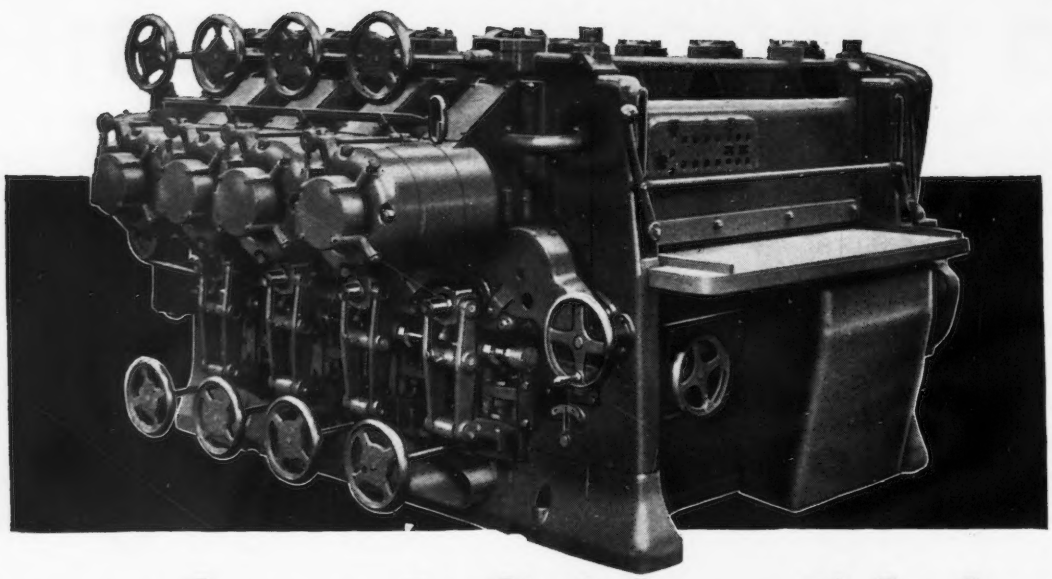

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eliminates chip-tearout problems

Mills using Yates-American Double-Deck Sanders come up with performance figures that are eye-openers!

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With the Yates Sander, finishing particle board is done in *one* operation:

It removes up to 3/16″ of stock (depending upon density of board) —at rates up to 50 feet per minute. It holds tolerances of less than ±.002″ over an entire sheet — *that we guarantee!*

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V-W-9

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Both mills are finishing particle board with a Yates-American Double-Deck Sander and are removing up to 3/16″ of stock. This is what they report on sandpaper life:

First two pairs of drums.....1200 to 1500 hours
Third pair of drums..... 500 to 700 hours
Fourth pair of drums..... 150 to 200 hours

We repeat — these are not *our* figures. They've been furnished to us by *two different mills* and have been confirmed and re-confirmed.

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- **Dissolves *instantly* into creamy, free-flowing mix.**
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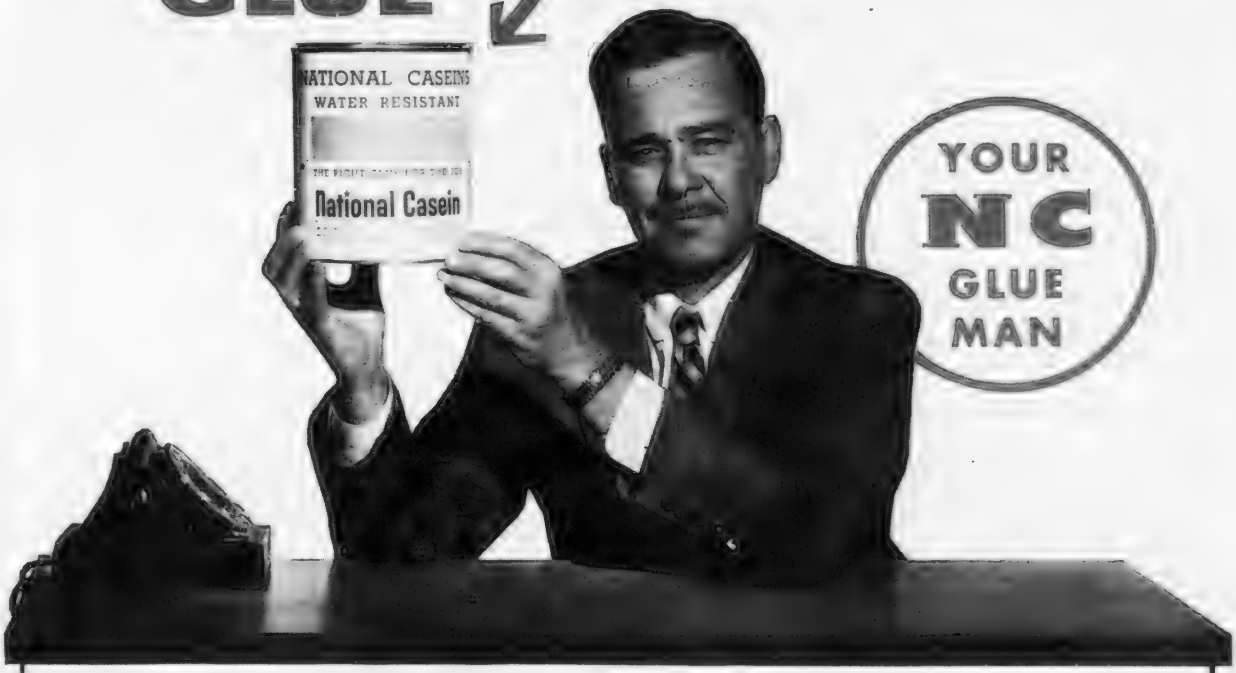

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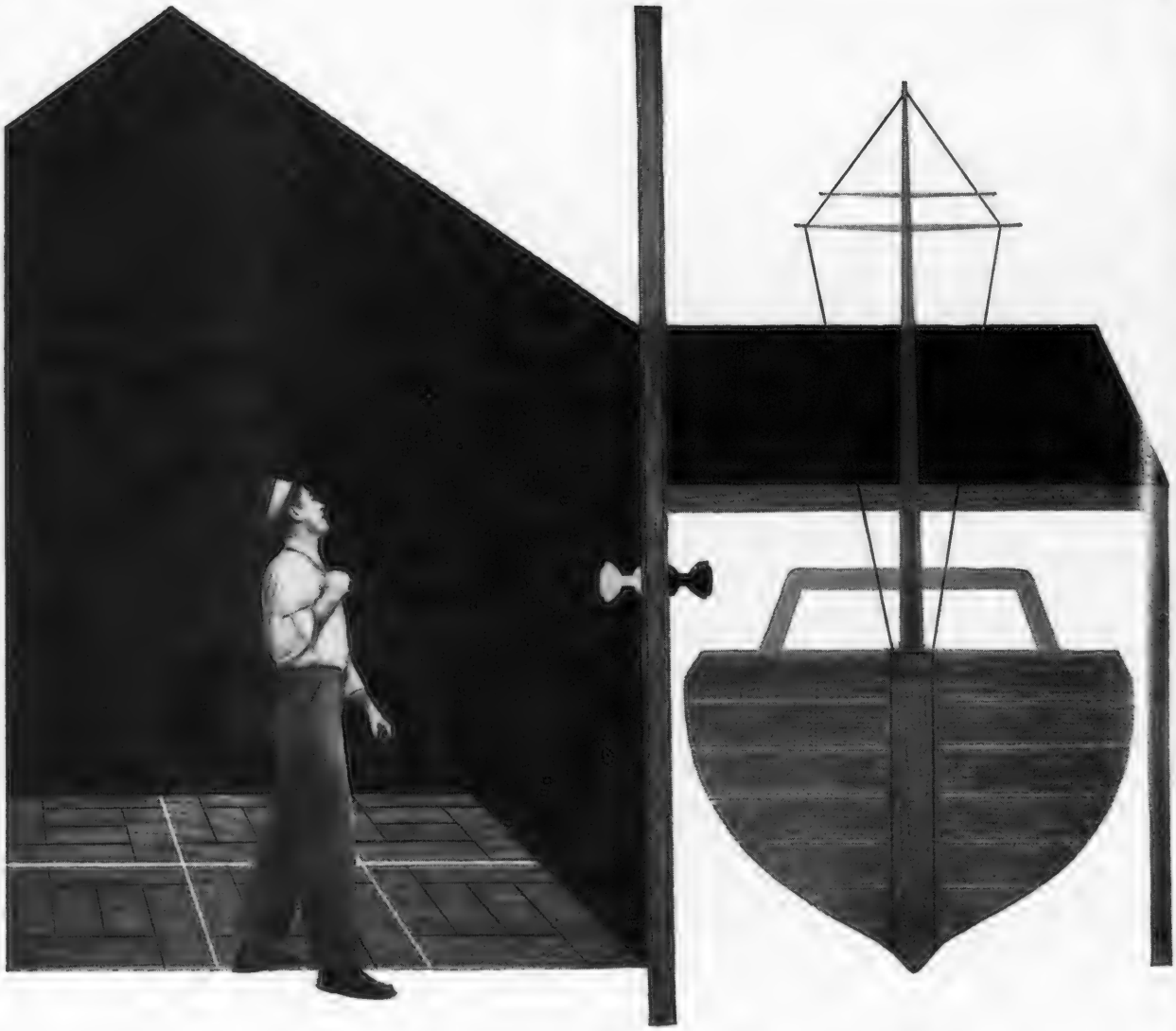

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MELAMINE

Monsanto melamine resin, LAUXITE MF-300, provides a completely waterproof bond—for boats, exterior doors and paneling, scarfing lumber and parquet flooring.

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Melamine has excellent washability. It may be used immediately after urea-formaldehyde resin without a cleanup. LAUXITE MF-300 is furnished as a dustless powder and can be easily formulated to meet *both* minor and major durability problems.

LAUXITE MF-300 bonds meet military as well as rigid civilian specifications. This resin is recommended as a straight adhesive (for either hot press or radio frequency gluing operations) or for upgrading urea formulations.

LAUXITE MF-300 can be economically formulated to meet your requirements for waterproof bonding. Write today for test samples and data sheets. Monsanto Chemical Company, Plastics Division, Room 469 Springfield 2, Mass.

*LAUXITE: REG. U.S. PAT. OFF.

MONSANTO

Eliminate arcing and burning from your electronic wood bonding operation

NEW

THERMATRON
Automatic Electronic
ARC SUPPRESSOR*

Type AS-3W

Saves costly electrodes and materials by anticipating any arc before damage occurs. Spoilage and expensive down-time are reduced to a bare minimum with this compact new arc suppressor with microsecond response. It detects when arcing is about to happen and cuts off the power instantly. A buzzer and flasher light indicate that the unit has functioned — then the electronic generator is recycled for the next operation.

The new Arc Suppressor, boon to thousands of Thermatron welding installations in the plastics field, is now available to the entire woodworking industry. Developed by Thermatron engineers as another step toward trouble-free electronic gluing, it affords maximum protection and is designed for installation on any RF generator.

Thermatron engineers will gladly tell you more about this latest refinement in electronic bonding . . . Write for complete details to Dept. FP-1

Would you also like information on electronic bonding equipment for your particular requirements? There are Thermatron generators and presses large and small for every purpose.

*PAT. PENDING

Thermatron Division
RADIO RECEPTOR COMPANY, INC.
In Radio and Electronics Since 1922

Thermatron®
HIGH FREQUENCY SEALING AND HEATING EQUIPMENT

SALES OFFICES: 251 West 19th St., New York 11, N.Y. WAtkins 4-3633
Chicago: 2753 West North Ave.
Factories in Brooklyn, N.Y.
OTHER RADIO RECEPTOR PRODUCTS: Radar, Navigation and Communications Equipment; Selenium Rectifiers; Germanium and Silicon Diodes

"We Chose PENACOLITE® Adhesives For This Special Bonding Application"

. . . says Harold West, Mill Foreman
Kaplan Furniture Company,
Cambridge, Massachusetts

Makers of the Beacon Hill Collection

Worker checks position of a package of veneer sheets spread with PENACOLITE adhesives.

It was during World War II, when assembling tail sections of troop-carrying gliders, that Kaplan Furniture Company first used PENACOLITE adhesives. The Company has since continued to use them to bond all its finest veneer finishes—both flat and curved.

"PENACOLITE adhesives," says Mr. West, "have reduced checking of veneer surfaces by 60 to 80 per cent, and provided a completely waterproof bond that resists the dissolving effect of bleaching. In fact, we have run tests under steam and soaked bonded pieces in water for weeks on end, and the adhesives have never failed, even when the pieces were force-dried under heat.

"Furthermore, PENACOLITE adhesives have introduced a new versatility into our drying process by completely eliminating the need for heated cauls in our veneering operation. This allows a longer closed-assembly period, affording us valuable time to more carefully position veneer and cores."

Why don't *you* consider PENACOLITE adhesives for your particular wood-bonding job? Send for our FREE illustrated booklet describing their many advantages and versatility of application. Koppers Company, Inc., Chemical Division, Pittsburgh 19, Pennsylvania.

Veneer sheets are fed through the glue spreader while others are being stacked for forming and drying.

Their veneered surfaces having been bonded with PENACOLITE adhesives, these finished tables await the staining process.

KOPPERS

PENACOLITE®
RESORCINOL ADHESIVES

SALES OFFICES: PITTSBURGH · NEW YORK · BOSTON · PHILADELPHIA · ATLANTA · CHICAGO · DETROIT · HOUSTON · LOS ANGELES · SAN FRANCISCO
In Canada: Dominion Anilines and Chemicals Ltd., Toronto, Ontario

Here's why

BUSS CABINET SURFACERS

ARE UNMATCHED FOR PRECISION PLANING

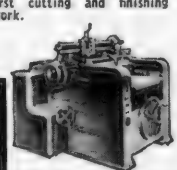
No. 44 Single Surface, 4 roll planer for first cutting and finishing work.

It takes a good mechanic exercising real skill and taking plenty of time for adjustments to produce first class finished planing on the conventional machine. On the other hand, an average operator will *consistently* produce ideal finished planing on a modern BUSS CABINET SURFACER and maintain tolerances as close as .002 an inch with only about one-third the non-productive time for set-ups and adjustments required on other planers. This is due to the fact that in addition to being built throughout for precision planing, BUSS CABINET SURFACERS are equippd with semi-automatic controls (not available on other machines) which make it easy for the operator to get perfect and almost instant settings. For the greatest production of the kind of planing that saves time on following operations, investigate BUSS CABINET SURFACERS. Write for bulletins. Consult us on any planing problem.

THERE'S A BUSS PLANER TO EXACTLY SUIT YOUR NEEDS

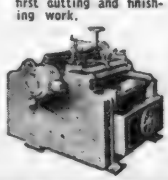
6 MODELS
29 SIZES

No. 4-L Single Surface, medium sized planer for first cutting and finishing work.



No. 66 Single Surface, 6 roll planer for first cutting and finishing work.

No. 88 Double Surface, 8 roll planer for first cutting and finishing work.



No. 55 Heavy Duty Double Surfacer for planing rough lumber.

MICRO-SURFACER for planing hardboard and other very thin materials.

BUSS
SINCE 1862
MACHINE WORKS

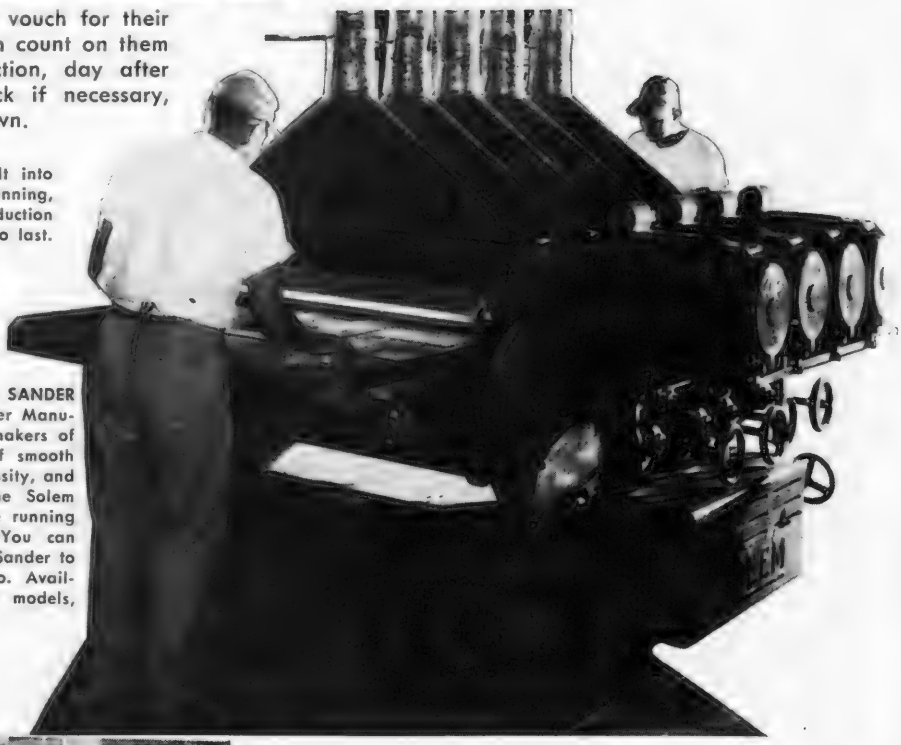
PLANER SPECIALISTS EXCLUSIVELY

292 EIGHTH STREET • HOLLAND, MICHIGAN

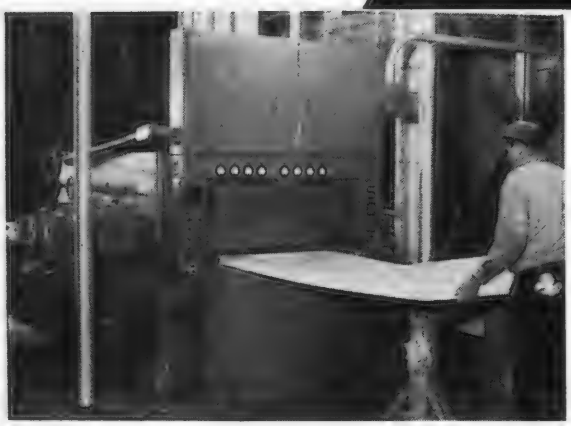
DEPENDABLE!

Every Solem User will vouch for their dependability. You can count on them for continuous production, day after day, around the clock if necessary, with never a breakdown.

It's the Quality That's Built into Them that keeps them running, where others fail. True production machines,—they are built to last.

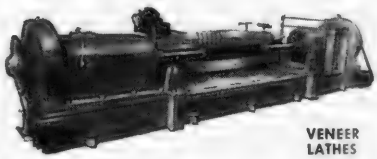


SOLEM ENDLESS-BED FOUR-DRUM SANDER seen here in operation at the Keller Manufacturing Co., Corydon, Indiana—makers of furniture. Here rapid production of smooth finished panels and parts is a necessity, and the low costs obtainable with the Solem Sander helps keep this firm in the running in this highly competitive field. You can probably use a Solem Endless-Bed Sander to advantage in your production, too. Available in two, three and four-drum models, in widths from 31" to 85".



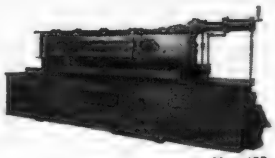
SOLEM DOUBLE-DECK SANDERS . . Here's the Solem Double-Deck Eight-Drum sander in operation in a large fir plywood plant in Oregon. It smooths both sides at the same time, to a fine sanded finish. You get safe operation; each drum is push-button controlled and provides ultra-high production . . All this along with Solem Dependability.

SOLEM'S affiliate—Merritt–Solem Division, of Lockport, New York, makes the lathes, clippers and jointers shown below, for the veneer and plywood industry. Many sizes and models but the same Solem Dependability.



VENEER LATHES

VENEER CLIPPERS



VENEER JOINTERS

HIGH PRODUCTION, SMOOTH FINISHES, SOLEM DEPENDABILITY is what you get from Solem Sanders. There's a size and model to suit your particular need, and it's engineered for the job it is to do. The low maintenance cost assures you a constant profit on the work turned out. Solems are favorites wherever there is wood to be sanded smooth. Whether you make plywood, millwork, finished furniture or pianos, you'll make it smoother with a Solem Sander.

FOR MORE INFORMATION, WRITE TODAY TO

SOLEM MACHINE COMPANY

ROCKFORD **ILLINOIS**

Let's Face It!

THERE IS NO MAGIC WAY TO MAKE OLD MACHINES NEW AGAIN

Sure they can be rebuilt to run about as well as they ever did . . . but woodworking plants operating these old machines are not making a profit now. Look in your own shop. Count the questionable machines that may be losing money for you every day.

Profitable woodworking demands high production, accurate size and low cost per piece. Modern machines have many new speed and convenience factors built into them. Modern machines provide higher production, greater accuracy, lower costs and a profit for you.

New machines attract the best help . . . modern craftsmen who use more headwork and less backwork. Are old machines keeping this best help from your door?

Put a profit in your woodworking with MODERN MACHINES

WOODWORKING MACHINERY MANUFACTURERS' ASSOCIATION — WMMA

WOODWORKING MACHINERY MANUFACTURERS ASSOCIATION

1900 ARCH STREET
PHILADELPHIA, PENNSYLVANIA

WOODWORKING MACHINERY MANUFACTURERS ASS'N.
1900 ARCH ST., PHILADELPHIA, PA.

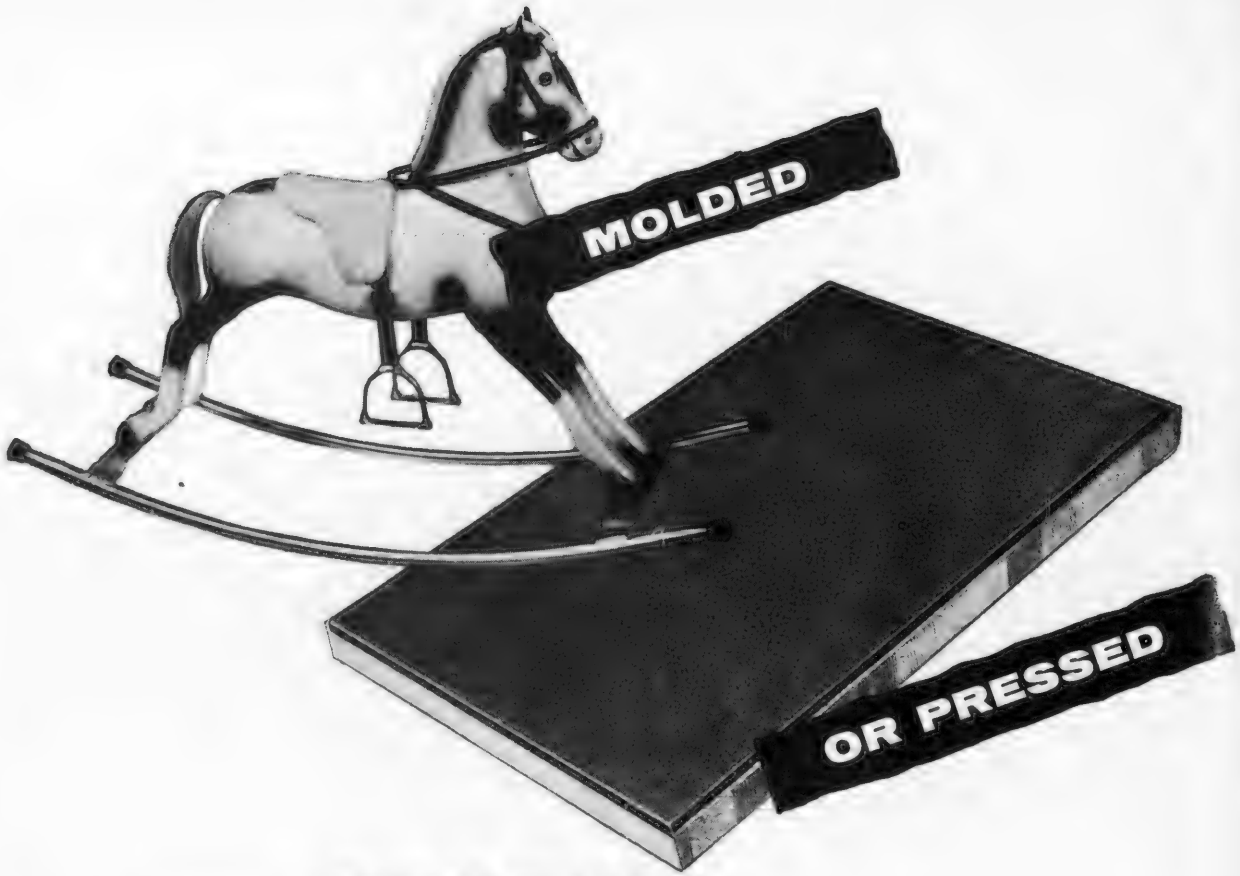
Please send further information. I am interested in the following types of machinery_____

Name_____

Company_____

Address_____

City_____ Zone ____ State _____



Today's **PROFITS FROM** *yesterday's* **WASTE**

...with **DUREZ** *Phenolic Resins*

Molded articles and pressed board made of wood particles bonded with Durez phenolic resins have opened up profitable new uses for wood material previously wasted.

Particle board can be made with these resins in a variety of densities, strengths, hardnesses, and other mechanical properties, and in various thicknesses. It can be machined or worked readily with ordinary equipment. Toys, household articles, toilet seats, and chair backs and bottoms suggest the broad commercial markets open to compression molded wood products.

Supplied in powdered form, Durez wood-bonding resins offer maximum ease in processing. When cured or solidified they exhibit physical properties that are suitable for these numerous end-products.

If you are inquiring into the profitability of particle wood in your operations, or are already producing it, we can help you. Qualified field experts, backed by our long experience in research and development, are available for consultation.

DUREZ®

Phenolic Resins for the Wood Industry

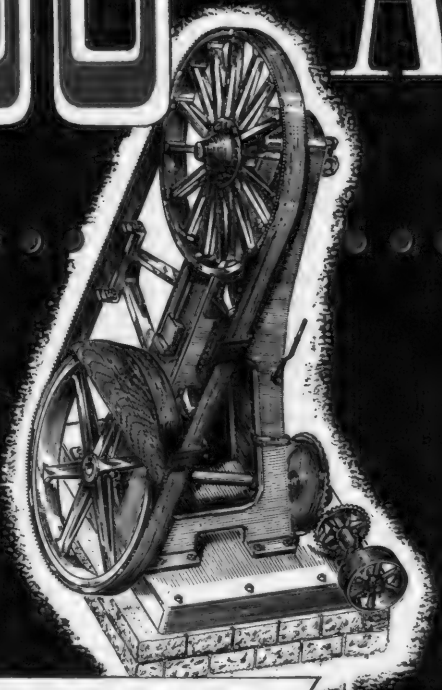
HOOKER CHEMICALS PLASTICS

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY

3915 WALCK ROAD, NORTH TONAWANDA, N. Y.

100th Anniversary



1856
1956

BAND MILL • • •

In 100 years of manufacturing sawmill machinery, Filer & Stowell Company was responsible for many of the improvements in machinery used throughout the lumber industry today.

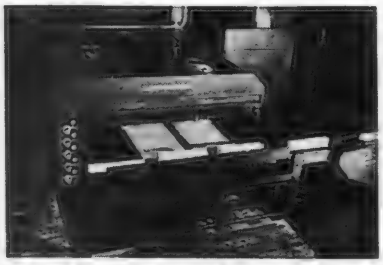
Shown above is one of Filer & Stowell's current band mill models. Compare it to one of its predecessors, The Cunningham Diagonal Band Mill. The Cunningham was developed before the 1880's and many of its parts were made of wood. The rim and spokes of the upper wheel, for instance, were all wood. It was inclined because engineers of that time believed it was easier to saw a log on an angle in the same manner as the wood cutters did in their wood yards.

WORLD'S LARGEST BUILDERS OF HEAVY DUTY SAWMILL MACHINERY

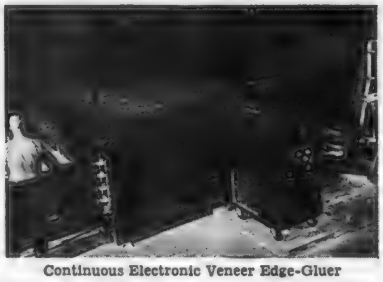
For Complete Information on Current Filer & Stowell Band Mills, Write for Bulletin No. 300

The Filer & Stowell Company

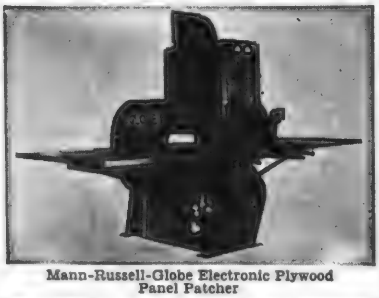
MILWAUKEE 7, WISCONSIN



Mann-Russell Continuous Electronic Lumber Edge Gluer



Continuous Electronic Veneer Edge-Gluer



Mann-Russell-Globe Electronic Plywood Panel Patcher

Mann-Russell Electronic Scarf Gluing Press

what's your glue line?

If you edge-glue lumber, veneer, do panel repair patching, scarf plywood . . . laminate structural beams . . . do ANY type of gluing, with soft or hard woods . . . Mann-Russell can **Speed Your Production . . . Cut Costs**

No matter what **your** glue-line problems may be, Mann-Russell can offer a solution that will increase production, reduce overhead, provide greater utilization of shorts and waste stock.

Mann-Russell equipment is engineered, and single responsibility assumed, for the specific job . . . installed and serviced by factory engineers. Why not glue the **modern** way — electronically? Write, wire, or call . . .

Mann-Russell Electronics
(NORTHWEST SYNDICATE, INC.)

PLANT: South 23rd & Pacific Avenue
Tacoma 2, Washington
FUlton 1593

New developments from DIEHL...

NO. 909 FEATURES:

- Low-cost, initial investment.
- Easily adjustable table.
- Minimum lubrication—minimum maintenance.
- Rigid—free from vibration.
- Hinged feed roll cover.
- Easily removable saw sleeve and spur sleeve.
- All upper feed rolls easily removed.
- Enclosed roll drive assembly.
- Five powered feed rolls.
- Precision balanced arbor motor.
- Four feed speeds—50-115 fpm.
- Quickly adjustable stock gauge.
- Designed for carbide-tipped saw blades.
- All controls grouped for easy operation.
- Sealed dust pits.
- Safety throughout.

New low-cost, top-quality No. 909 Multi-Rip Saw

The new Diehl No. 909 Multi-Rip Saw offers the woodworking industry a low-cost, top-quality machine—specifically designed for precision, high-speed gang ripping of stock as short as 5 inches.

The No. 909 is compact and rigidly constructed, with arbor and arbor motor mounted *on the frame.* It has an *easily adjustable, reinforced, one-piece table*—a feature not usually offered in a low price machine of this type. The table adjusts to a 4 inch maximum, and permits cutting of throat plates in operative position.

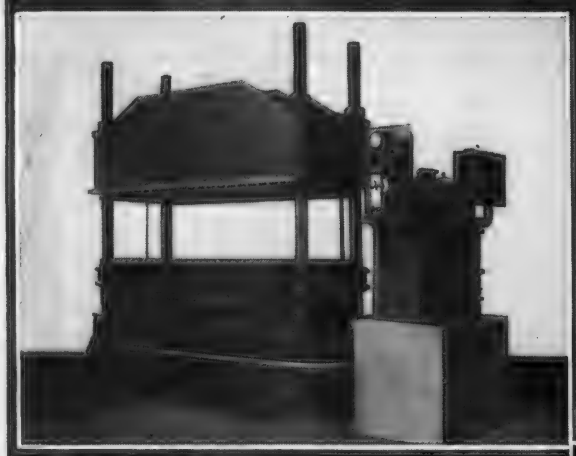
For volume production, the Diehl No. 909 offers 4 standard feed speeds from 50 to 115 fpm. Higher speeds to 153 fpm are optional. Other features include: rips stock from 1/8 to 2½ inches thick, and from 5 inches to infinite length; controls are grouped for easy operation; five powered feed rolls; easily removable saw sleeve and spur sleeve; all upper feed rolls easily removed; maximum operator protection is assured—for the No. 909 has 54 anti-kick-back fingers, arranged directly at the infeed end—all electrical controls, gears, chains and belts are adequately enclosed or covered.

Write today for complete information on the new Diehl No. 909 Multi-Rip Saw. Request Bulletin MRS-909 . . . or see your nearby Exclusive Diehl Representative.

THE G. M. DIEHL MACHINE WORKS, INC.
WABASH, INDIANA

Standard of Comparison in the Woodworking Industry . . .

Diehl



If your company is expanding or if you are "new comers" in the plywood, veneer or hardboard field, consider WILLIAMS-WHITE & CO. custom built hot or cold presses before you buy! Built to your exact requirements, WILLIAMS-WHITE presses represent the peak of up-to-date design and craftsmanship.

Your specifications as to capacity, plate size, number of openings, types of controls, etc., are built into each WILLIAMS-WHITE hot or cold press. They are available in column or A-frame construction, with steam, fluid or electrically heated plates.

Above is illustrated a WILLIAMS-WHITE 250 Ton Hot Plate Press with platens 96" x 48" and adjustable daylight openings of 24", 30", 36" and 48". Equipped with automatic pushbutton control.

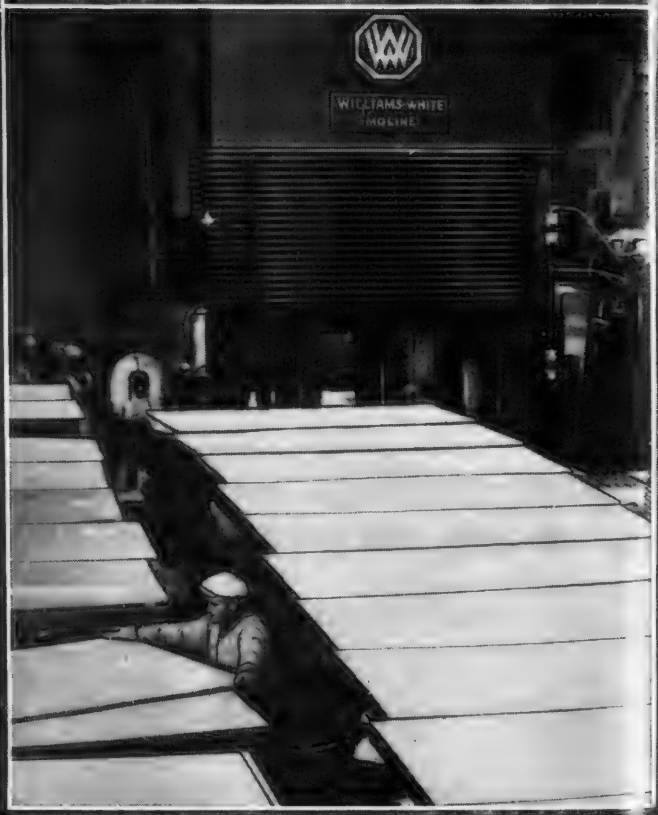
The press illustrated at right is a 20- opening plywood press, capacity 1485 Tons, with platens 106" x 56", in use in a plant in the Pacific Northwest.

REPRESENTATIVES:

ALLIED NORTHWEST MACH. TOOL CORP.
Portland, Ore.

GEORGE A. DAVIES, JR., MACH. CO.
Los Angeles, Calif.

WILLIAMS-WHITE & CO.
Chicago Office, J. E. Maynard, Mgr.
53 W. Jackson Blvd.



WILLIAMS-WHITE & Co.

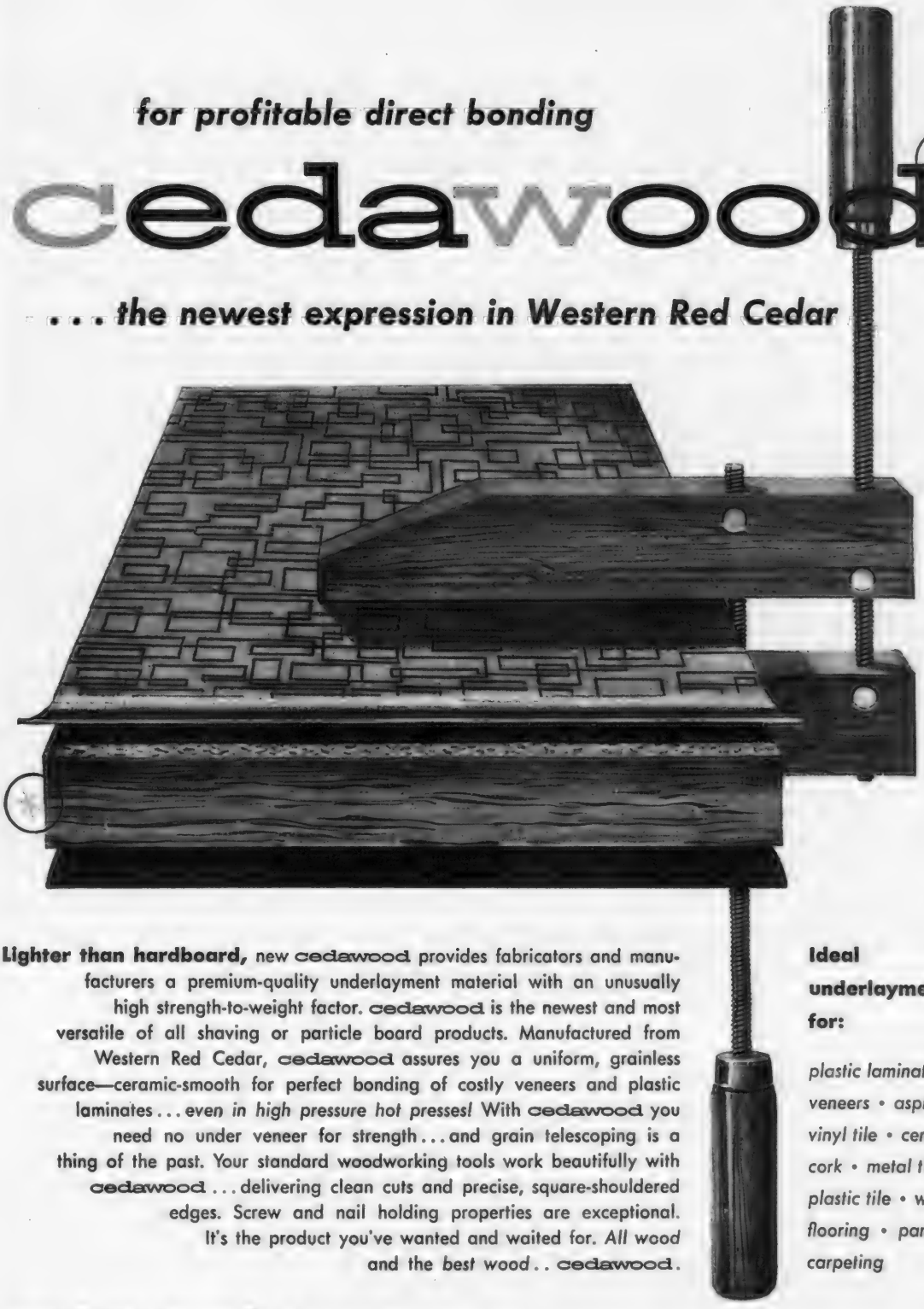
401 EIGHTH ST. • MOLINE, ILLINOIS

PRESSES • BULLDOZERS • BENDERS • PUNCHES • SHEARS

for profitable direct bonding

cedawood®

. . . the newest expression in Western Red Cedar



Lighter than hardboard, new cedawood provides fabricators and manufacturers a premium-quality underlayment material with an unusually high strength-to-weight factor. cedawood is the newest and most versatile of all shaving or particle board products. Manufactured from Western Red Cedar, cedawood assures you a uniform, grainless surface—ceramic-smooth for perfect bonding of costly veneers and plastic laminates . . . *even in high pressure hot presses!* With cedawood you need no under veneer for strength . . . and grain telescoping is a thing of the past. Your standard woodworking tools work beautifully with cedawood . . . delivering clean cuts and precise, square-shouldered edges. Screw and nail holding properties are exceptional. It's the product you've wanted and waited for. *All wood and the best wood . .* cedawood.

Ideal underlayment for:

plastic laminates • veneers • asphalt tile • vinyl tile • ceramic tile • cork • metal tile • plastic tile • wall cloth • flooring • panelling • carpeting

cedawood *THE NEWEST PRODUCT OF:*

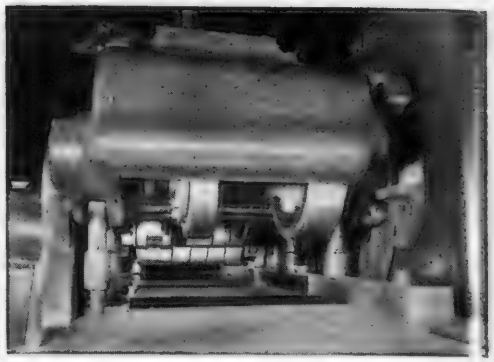
COLUMBIA HARDBORD CO. . 560 SKINNER BUILDING, SEATTLE 1, WASHINGTON

Plant and process by Industrial Development Company, Inc., Tacoma 2, Washington

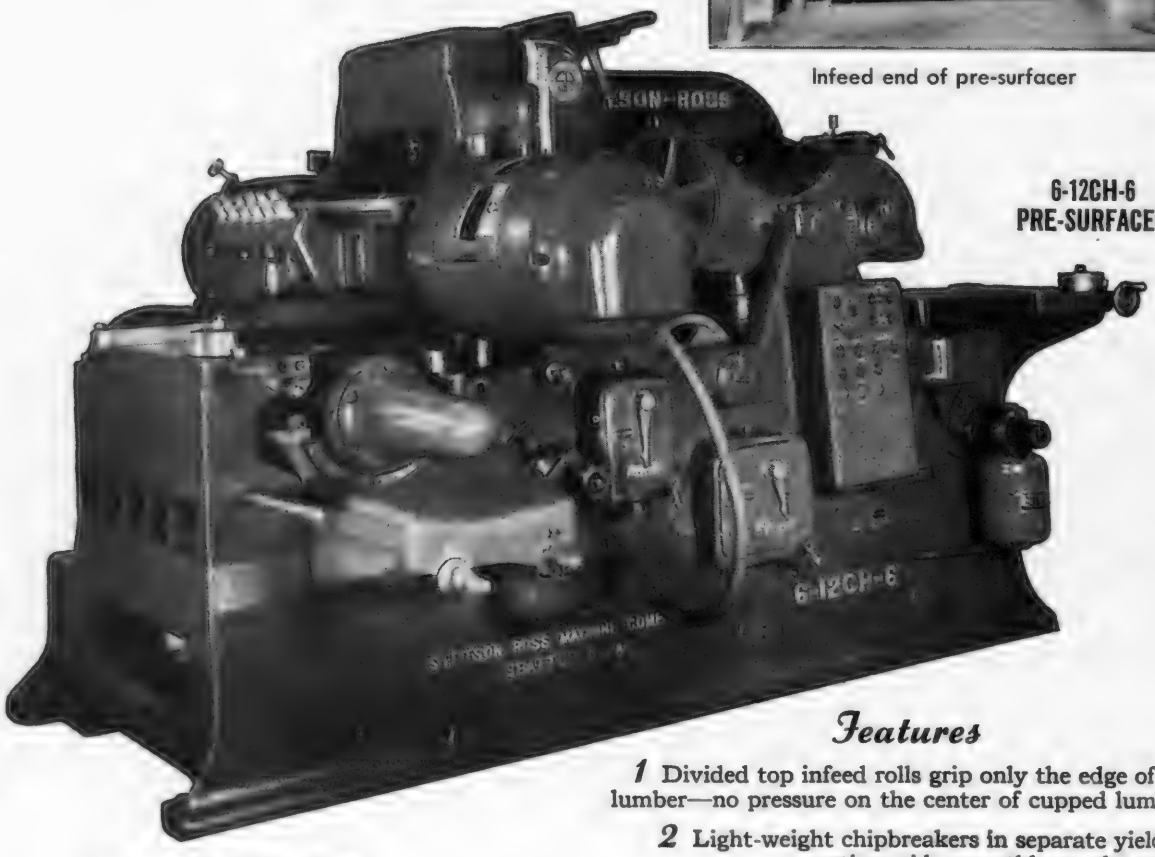
STETSON ROSS

PRE-SURFACER

Reduces "Roll-Split" 80 to 90%



Infeed end of pre-surfacer



6-12CH-6
PRE-SURFACER

Features

1 Divided top infeed rolls grip only the edge of the lumber—no pressure on the center of cupped lumber.

2 Light-weight chipbreakers in separate yielding sections ride smoothly on the stock.

3 Sectional spring-loaded pressure bar over bottom cylinder exerts minimum pressure on the face of the lumber.

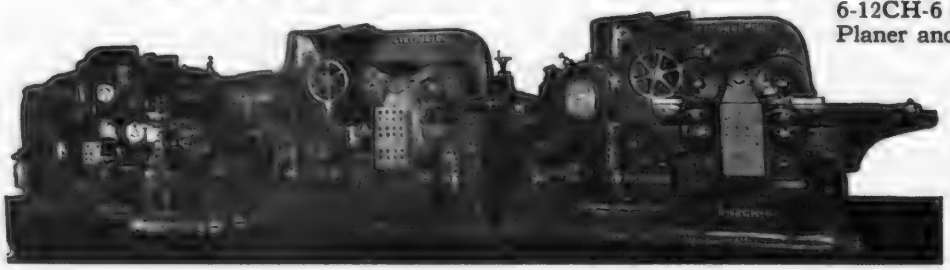
This machine adjoins a regular Planer and Matcher of any make. A single feed motor drives both Planer and Matcher and Pre-Surfacer. 6-12CH-6 Pre-Surfacer with 6-12-C1 Planer and Matcher are shown here.

Customers for Stetson-Ross Pre-surfacers include:

★ J. Neils Lumber Co., Libby, Montana

★ Potlatch Forests, Lewiston, Idaho, 2 machines

★ Intermountain Lumber Co., Missoula, Montana



You are invited to write for information on saving lumber through pre-surfacing.

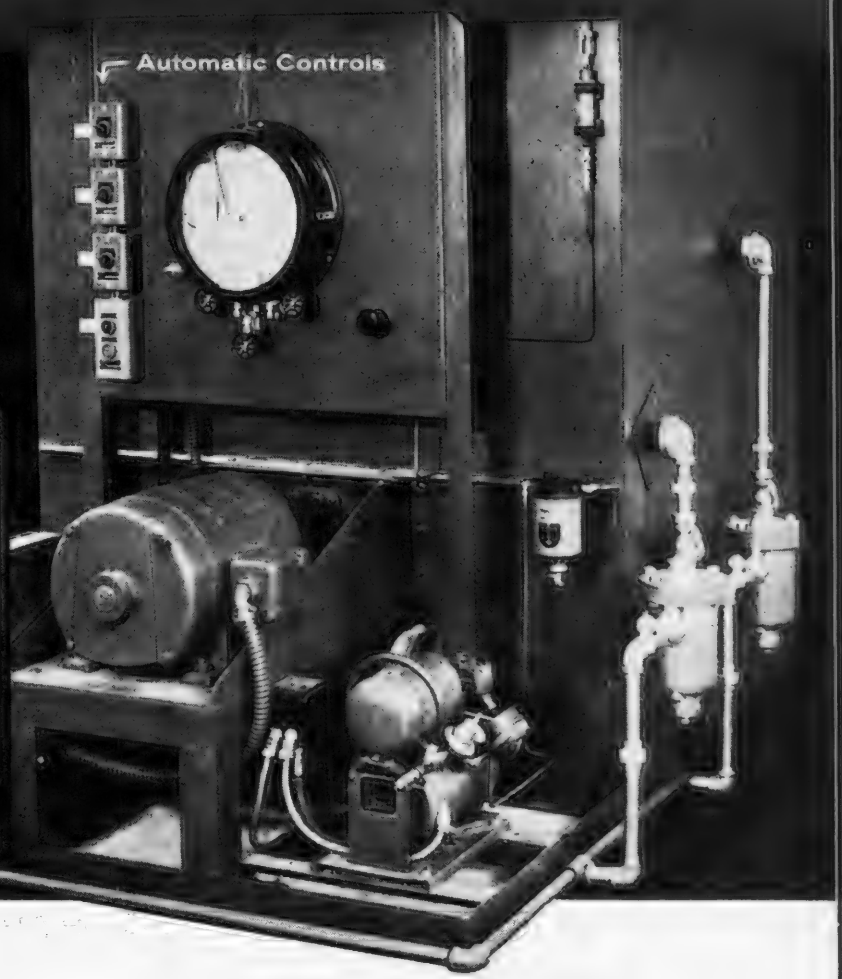
STETSON-ROSS MACHINE COMPANY, INC. • SEATTLE 4, WASHINGTON • EXPORT DIVISION 301 CLAY ST., SAN FRANCISCO, CALIFORNIA

NEW DRYALATOR® dries lumber

3 TO 5 TIMES FASTER

Saves Up to 2/3 on Initial Investment

BRINGS AUTOMATION TO LUMBER DRYING!



OPERATES AUTOMATICALLY

Using new engineering principles, the O&S packaged DRYALATOR automatically draws moisture out of any species of lumber *faster and better* than ever before possible . . . actually reduces drying time from days to hours! Ample evidence is available of the superior performance of the DRYALATOR over other kiln equipment in drying various kinds of lumber. Automatic controls give you push-button operation, permitting a constant and accurate moisture check without stopping the drying or opening the kiln.

SAVES SPACE, INVENTORY COSTS

Because of DRYALATOR's high speed and quality seasoning, only a small kiln is required. Existing kilns can be inexpensively converted to DRYALATOR operation. This new system eliminates the high costs of custom drying and allows profitable assembly line production with reduced inventories.

Engineering assistance in adapting DRYALATOR to your woodworking operations and follow-up service is provided by a nation-wide organization of factory-schooled O&S representatives.

Investigate the cost-saving benefits to your plant of this revolutionary new drying system. Write today for DRYALATOR bulletin.

O&S PACKAGED DRYALATOR®

WOOD AND LUMBER DRYER

ORR & SEMBOWER, INC.

Morgantown Road, Reading, Pa.

Builders of Heat Transfer Equipment for over 70 Years

PROTECTION PRODUCTS

A Name That Means What It Says . . .

Through the past 30 years, leading manufacturers, mills, lumber yards and users of wood products have learned to look to PROTECTION PRODUCTS for water repellents and wood preservatives of superior quality. A clear recognition of the needs of the industry, sincere efforts to serve those needs, plus advanced research are **BIG** reasons why PROTECTION PRODUCTS maintains its position of leadership. Most likely, PROTECTION PRODUCTS also holds the answer to your wood preservative needs.

WOODLIFE — *The Original* WATER REPELLENT PRESERVATIVE — containing PENTAchlorophenol

. . . **the original water repellent wood preservative.** Contains PENTA and other chlorinated phenols (or straight PENTA to meet Federal Specifications) for protection against fungus, decay and stains, termites and other wood destroying insects. Highly water repellent to retard dimensional change, warping and checking. Ideal as a paint base to forestall peeling and blistering. Widely used by NWMA licensees. WOODLIFE is consistently outstanding in precise laboratory comparisons and famous for performance on the job.

Boxlife

. . . **water repellent "Life Assurance" for field boxes, crates, hampers.** Containers treated with BOXLIFE are protected against rapid weathering and stand up well under the rigors of steam cleaning. Nails stay brighter and tighter. Splitting and breakage are minimized. No odors—No tastes—No contamination. For an Antiseptic water repellent BOXLIFE-C containing solubilized Copper 8 quinolinolate and BOXLIFE-O containing orthophenylphenol have been specially formulated to aid in the reduction of spore count—Protection against decay—highest possible sanitation. Investigate treatment with BOXLIFE, BOXLIFE-C and BOXLIFE-O—You'll be amazed at the low cost highly effective results.

Woodlube

. . . **combines highest water repellency with wood lubrication.** WOODLUBE is widely used in furniture manufacturing where the "slidability" of wood and dimensional control are important. WOODLUBE is used on photo engraving blocks, shuttles and bobbins in the textile mills, cement form material, wood bearings—wherever an easy-to-apply, inexpensive and highly effective water repellent and lubricant is needed. Where finishability is also desired WOOD-YOUTH is used.

P.A.R. — PROTECTS — RESTORES *the Beauty of Wood*

. . . **developed as a water repellent for redwood,** cedar, mahogany and other dark woods. Whether the Clear is used, for natural grain color—or **Pigmented,** for that deep warm appearance, P. A. R. "PROTECTS and RESTORES" the natural beauty of siding, fences, trim or paneled interiors. Clear P. A. R. is also often used as a base for color blending.

PENTA CHLOROPHENOL — WOOD PRESERVATIVE — WOOD THAT IS NOT TO BE PAINTED

. . . low cost, long term insurance for wood that is not to be painted . . . fence posts, bar poles, sheds, etc. PENTA treated wood is impervious to attack by termites and other wood destroying insects. Available as a concentrate or in ready-to-use formulations.

PROTECTION PRODUCTS

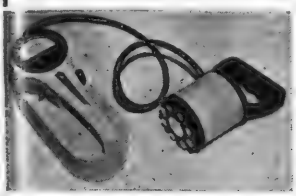
Quality Is the Price of Leadership

PROTECTION PRODUCTS MANUFACTURING CO.

KALAMAZOO MICHIGAN

MOISTURE REGISTER

- Insures quality, tells moisture content for best woodworking results.
- Saves you money, helps cut freight costs.
- Protects your purchases, makes sure orders are filled correctly.
- Increases customer goodwill by insuring your deliveries to meet customer requirements.



Moisture Register Model RF4 with push-button electrodes.

Moisture Register instruments test moisture content in wood and wood products down to 0% with guaranteed performance. There's a model for every purpose, both radio frequency and needle types, priced for every budget. New models now available for wood waste and plaster. 10-day free trial offer. No obligation! Write today, outlining your requirements. Ask for information on Moisture Register instruments specially designed for the textile, leather, paper and wood industries.

MOISTURE REGISTER CO.
1510 West Chestnut St. Alhambra, Calif.

CURVED PLYWOOD?

Made to specification

High-Frequency bonding on low cost forms

Tell us your problem — we'll solve it to your specifications. We manufacture unusual plywood shapes for applications ranging from church pews to water skis . . . table legs to torpedo cradles. Our high-frequency presses mass-produce curved parts fast and at lower cost than other methods, and with greater stability. We have over 200 stock dies available for stock shapes. Write, wire or phone RI 2-2474 for quotations and complete engineering service.

PLY-CURVES INC.

1515 Monroe Avenue, N.W., Grand Rapids 5, Michigan

New Rockwell-built DELTA POWER FEED UNIT...

... makes possible the LOWEST COST PRODUCTION RIPPING MACHINE on the market!

Delta's new Power Feed Unit is designed expressly for use with the rugged, versatile Delta 12" Tilting Arbor Saw. Together, this team gives you accurate, high-speed *production* ripping *at less cost* than most production table saws alone!

The new Delta Power Feed Unit is custom-engineered for *precision* . . . feeds accurately, insures straight cuts. For *speed* . . . selector dial control allows an infinite choice of speeds from 20 to 90 feet per minute. For *safety* . . . unit firmly grips stock after operator begins feeding.

It quickly swings down out of the way to give you full use of the versatile 12" tilting arbor saw for many extra jobs. *Your Delta Dealer is listed under "TOOLS" or "MACHINERY" in the classified pages of your phone book.*

DELTA ROCKWELL **DELTA** QUALITY POWER TOOLS

Another Product by **Rockwell**

DELTA QUALITY COSTS NO MORE

Send this Coupon for all the facts!

Delta Power Tool Division, Rockwell Manufacturing Company
700-K North Lexington Avenue, Pittsburgh 8, Pa.

☐ Please send me descriptive sheet on new Delta Power Feed Unit.

☐ Please send name of my nearest Delta Dealer who has both Delta Power Feed Unit and Delta 12" Tilting Arbor Saw on display.

Name _____ Position _____

Company _____

Address _____

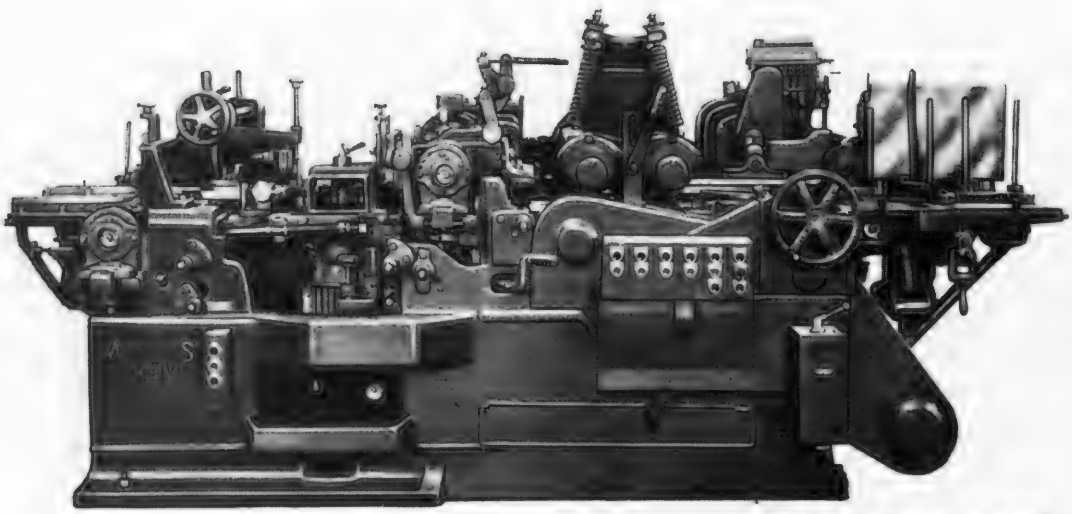
City _____ Zone___ State_____

Serving the Industry Since 1852

It's Marvelous!

This "LAG BED" MOULDER

built by "The Moulder of Woods"®



134 Woods Moulder, shown with hopper feeding attachment

The new Woods 134MT Moulder Series bring to the Industry, a new concept in spindle design, the Woods *tapered spindle*. Your production costs go down, your production rate increases, with Woods *tapered spindles*.

Cutterhead sleeves and bushings are eliminated, securing more rigid cutterhead fit on spindle. Removal and mounting of cutterheads becomes a matter of moments—a simple and easy operation. Let us tell you more about Woods *tapered spindles* and the many other exclusive time and money saving features built into the new Woods 134MT Moulder Series.

S. A. WOODS MACHINE CO.®

27 DAMRELL STREET

BOSTON 27, MASS.

BRANCH OFFICES

ARKANSAS—Little Rock
NEW YORK—Mt. Vernon
CALIFORNIA—San Mateo
N. CAROLINA—Greensboro
OREGON—Portland
TENNESSEE—Memphis

CANADIAN

BR. COL.—Vancouver, Akhurst Machinery Co.
ONT.—Galt, Canada Machinery Co.

EXPORT DEPARTMENT

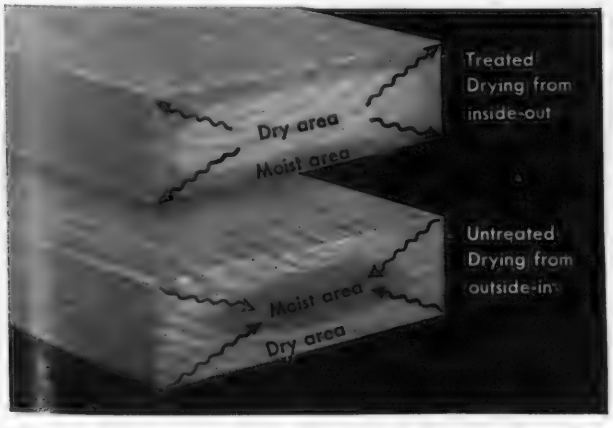
United States Machinery Co.
90 Broad St.
New York City

Manufacturers find it pays to use Morton Lumber Cure treated lumber

The Tell City Chair Company, chairmakers since 1865, and makers of the rocker shown at right, started using Morton Lumber Cure treated lumber two seasons ago. The results have been most rewarding. Tell City has found Morton Lumber Cure reduces drying time about one-third, increases cutting yield, and produces check-free lumber.

Hundreds of fabricators now insist on lumber that has been treated with Morton Lumber Cure. They know from experience Morton Lumber Cure increases utilization of rough cut lumber. Lumber also can be dried faster; kiln time and expense can be reduced, with a more rapid turnover of inventory and capital.

What's more, Morton Lumber Cure is compatible with stain-preventing agents . . . will not affect gluability . . . machinability . . . color or finish. Morton Lumber Cure is non-toxic and non-corrosive.



HOW MORTON LUMBER CURE WORKS Morton Lumber Cure reverses the normal drying action. Untreated lumber dries from the outside in. Morton Lumber Cure dries lumber from the *inside out*. This controlled drying greatly reduces checks, honeycomb, warping, and other types of wasteful surface and interior degrade.

SEND FOR MORE INFORMATION TODAY!

Bay Chemical Company

DIVISION

Morton Salt Company

120 So. La Salle Street, Dept. FPJ-10, Chicago 3, Illinois

Please tell me how Morton Lumber Cure can help *me* increase my sales and satisfy customers.

Name_____

Title_____

Company_____

Address_____

City_____ State_____

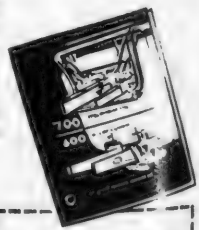
Lakeland Door Company, Trims Doors and Operating Costs with a Mereen-Johnson No. 600 DOUBLE CUT-OFF SAW

"We've realized big savings since our Mereen-Johnson No. 600 Double Cut-Off Saw was installed three years ago," according to B. A. Kennen, Superintendent of Lakeland Door Co., St. Louis Park, Minn. "Our production capacity is up over previous sawing methods and we now produce over 600 laminated wood doors—trimmed both directions—in an eight hour shift. If necessary, we could produce up to 1,000 finished pieces in the same time and still keep within the required close tolerances."

Quick set-up time is a feature of Mereen-Johnson equipment as provided by a patented snap dog arrangement that allows fast adjustments to be made for varying size doors with a minimum of downtime. Since most of Lakeland's work is "custom-tailored" for individual home contractors, sizes may vary as frequently as every five to ten doors trimmed. This requires fast adjustments to maintain scheduled production. "In a normal shift we may trim as many as 20 different size doors."

While the No. 600 is of medium size, it is well suited for this type of operation and it displays all the quality and workmanship of much larger units. The basic construction of the No. 600 is compact and allows for fast, easy adjustments. Maintenance is practically nothing!

The No. 600 Double Cut-Off Saw is available with trims only—or with tilting cope motors and stationary dado arbor. Special attachments are available as optional equipment.



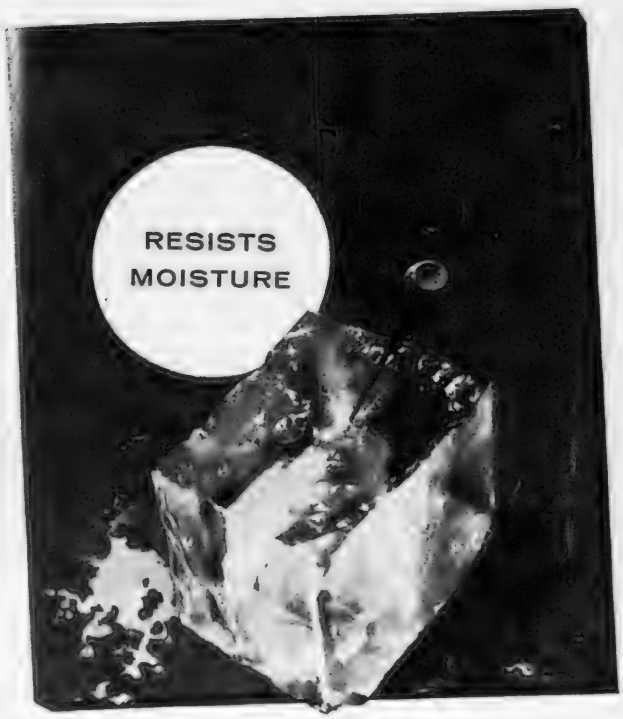
MEREEN-JOHNSON MACHINE CO.

4401 LYNDALE AVE. NO. • MINNEAPOLIS 12, MINNESOTA

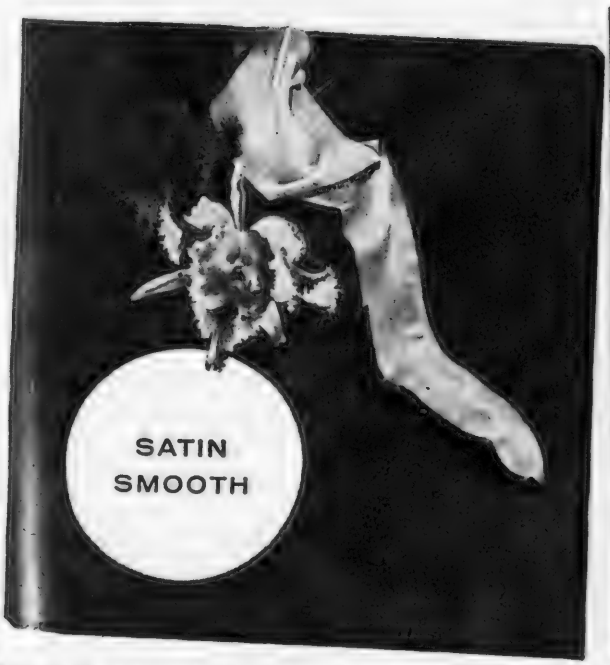
CUT OFF SAWS	DOUBLE CUT-OFF SAWS	MULTIPLE CUT-OFF SAWS	GANG RIP SAWS
TENONERS	VENEER & PLYWOOD SIZERS & JOINTERS		RESAWS

For complete specifications, write for illustrated Bulletin No. 600-700

Add extra quality...extra features
to your products with
MASONITE® PANELS



(44 types, textures and thicknesses for 1000 uses)



Finish with jointed steel knives

Finish with jointed Kennametal knives

Fifty-inch, solid KENNAMETAL* planer knives

★ **Increase production 100%**
★ **Eliminate "washboard" finish**
★ **Reduce maintenance costs**
★ **Improve dimensional accuracy**

Switching to 50-inch Kennametal carbide planer knives increased production and improved finish of both high-density and low-density hardboards.

Output of *steel* knives, in two working shifts or 16 hours per day, totaled 80,000 sq. ft. of hardboard. After almost every 3 hours, jointing was necessary and at the end of 16 hours of normal operation, the knives had to be completely reground. Maintenance required approximately 5 hours for each 16 hours of operation. In addition, it was difficult to maintain required finish and dimension because of the tendency of the steel knives and head to deflect, causing excessive "washboarding."

KENNAMETAL PERFORMANCE. Output with Kennametal knives, working two shifts or 16 hours, totaled 162,000 sq. ft. of hardboard. No jointing or grinding of these carbide knives was needed, thus requiring no machine downtime. After 14 eight-hour shifts of normal operation, Kennametal knives showed no evidence of wear. The rigidity of the solid Kennametal knives resists deflection; therefore, the board dimension is uniform and the finish is improved.

Why not try Kennametal knives in your operations? If you cannot get engineering service or carbide maintenance information from your present supplier, write to KENNAMETAL INC., Latrobe, Pa.

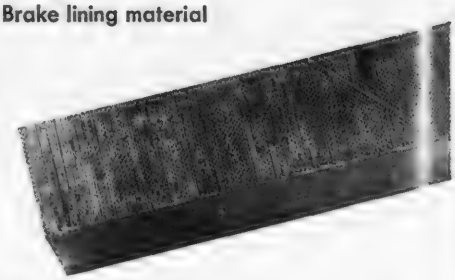
*Registered trademark

B-5934

These synthetics successfully planed with solid KENNAMETAL Knives

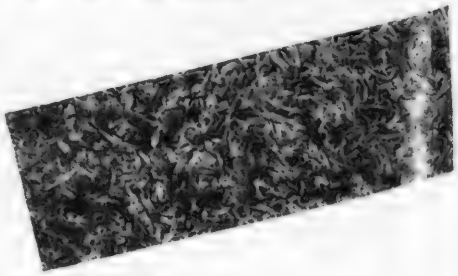
(Planing of these products with steel knives impractical)

Brake lining material

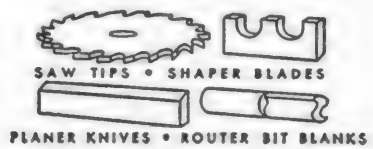


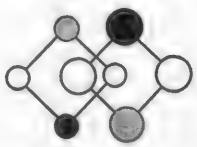
Phenolic fiber product

Hard rubber composition



Wood particle board





INDUSTRY AND
KENNAMETAL
...Partners in Progress

A NOTE TO THE FOREST PRODUCTS INDUSTRY

Have you checked this important source of

NEW IMPROVED RESINS!

From more than a decade of successful experience SYNCO RESINS are designed to give tops in all around performance. SYNCO phenolics and fortified vinyls are promptly available in liquid, dry, and emulsion forms for specific uses. Wide latitude in curing conditions includes room and intermediate temperature, hot pressing, and radio frequency bonding. SYNCO technical personnel will select the right resin and adapt it to your production to give you the advantages of:

WATERPROOFING

WEATHERPROOFING

TOUGHNESS AND DURABILITY

- *Binding Particle Boards and Dry and Wet Process Hardboards*
- *Gluing Dimensional Lumber*
- *Laminating Hardboards and Lumber*
- *Flush Door Construction*
- *Furniture Adhesives*
- *Resinated Paper Wood Overlays*
- *Metal to Wood Bonds*
- *Honeycomb to Wood Bonds*

SYNCO RESINS INC.

BETHEL CONN.

WRITE FOR FULL PARTICULARS: SYNCO RESINS, INC., BETHEL, CONN., U. S. A., TELEPHONE DANBURY Pioneer 85678

Meet FPRS 100 Company Supporting Members

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Dierks Forests, Inc., Mountain Pine
Southern Lumber Co., Warren

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California Redwood Association, San Francisco
L. J. Carr & Co., Sacramento
Crane Mills, Corning
Ivory Pine Co., Dinuba
Philadelphia Quartz Co. of California, Berkeley
Scott Lumber Co., Inc., Burney
Tarter, Webster & Johnson, Stockton
E. K. Wood Lumber Co., San Francisco

GEORGIA
Southern Wood Preserving Co., Atlanta

IDAHO
Boise Payette Lumber Co., Boise
Ohio Match Co., Coeur d'Alene

ILLINOIS
The Dean Company, Chicago
General Electric, Ill. Cabinet Plant, Rockford
Greenlee Tool Co., Rockford
Edward Hines Lumber Co., Chicago
Illinois Interior Finish Co., Chicago
Johnson & Carlson, Chicago
Masonite Corp., Chicago
Mattison Machine Works, Rockford
Sherwin-Williams Co., Chicago
Steger Furniture Mfg. Co., Steger

INDIANA
Kitchen Maid Corp., Andrews
The Dunbar Furniture Mfg. Co., Berne
National Homes Corp., Lafayette
The Wood-Worker & Veneers and Plywood, Indianapolis

IOWA
Curtis Co. Inc., Clinton

MARYLAND
J. I. Wells, Salisbury

MASSACHUSETTS
Draper Corp., Hopedale
Heywood-Wakefield Co., Gardner
A. G. Spalding & Bros., Inc., Chicopee

MICHIGAN
Baker Furniture, Inc., Grand Rapids
The Dow Chemical Co., Midland
Everett Piano Co., South Haven

MINNESOTA
Mereen-Johnson Machine Co., Minneapolis
Minnesota Mining and Mfg. Co., St. Paul
Rilco Laminated Products, Inc., St. Paul
Wabash Screen Door Co., Minneapolis
Winton Lumber Co., Minneapolis

MISSOURI
Monsanto Chemical Co., St. Louis

MONTANA
Intermountain Lumber Co., Missoula

NEVADA
Vaughn Millwork Co., Reno

NEW JERSEY
National Adhesives, Plainfield
Western Electric Co., Kearny

NEW YORK
American Defibrator, Inc., New York
Behr-Manning Corp., Troy, N. Y.
Borden Co., New York
Peter Cooper Corps., Gowanda
The New England Industries, Inc., New York
Oval Wood Dish Corp., Tupper Lake
Reichhold Chemicals, Inc., White Plains
United States Plywood Corp., New York
The Upson Co., Lockport

NORTH CAROLINA
Deluxe Saw & Tool Company, High Point

OHIO
American Machine & Foundry Co., Shelby
The Baldwin Piano Co., Cincinnati
Coe Manufacturing Company, Painesville
The Kirk & Blum Mfg. Co., Cincinnati

OREGON
Brooks-Scanlon, Inc., Bend
Cascades Plywood Corporation, Portland
Forest Fiber Products Co., Forest Grove
Mater Engineering, Corvallis
J. Neils Lumber Co., Portland
Oregon Lumber Co., Baker
West Coast Lumberman's Assn., Portland

PENNSYLVANIA
Koppers Company, Inc., Pittsburgh
Perkins Glue Co., Lansdale
United States Steel Homes, Inc., Harrisburg
Wood Metals Industries, Inc., Kreamer

SOUTH CAROLINA
Lightsey Brothers, Miley

TENNESSEE
E. L. Bruce Co., Memphis
Chapman Chemical Company, Memphis
Memphis Hardwood Flooring Co., Memphis
Nickey Bros., Inc., Memphis

TEXAS
Wm. Cameron & Co., Inc., Waco
Kirby Lumber Corporation, Houston
Love Wood Products of Texas, Diboll
Wynnewood Products Co., Jacksonville

VERMONT
Beecher Falls Mfg. Corp., Beecher Falls
Fyles & Rice Co., Inc., Bethel

WASHINGTON
American Marietta Co., Seattle
Biles Coleman Lumber Co., Omak
Cascade Lumber Co., Yakima
Columbia Plywood Co., Inc., Seattle
Deer Park Pine Industry, Inc., Deer Park
Diamond Match Co., Spokane
Douglas Fir Plywood Association, Tacoma
The Long-Bell Lumber Co., Longview
Simpson Logging Co., Shelton
Sumner Iron Works, Everett
Weyerhaeuser Timber Co., Tacoma

WISCONSIN
Harnischfeger Corp., Port Washington
Marathon Corp., Rothschild
Mosinee Paper Mills Co., Mosinee
D. J. Murray Mfg. Co., Wausau
Paine Lumber Co., Oshkosh

ALASKA
Ketchikan Spruce Mills, Ketchikan

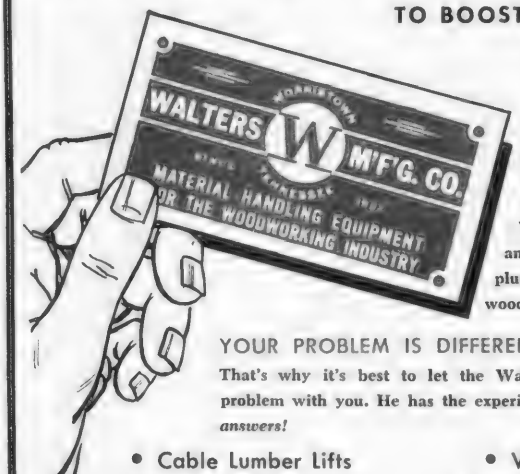
CANADA
B. C. Forest Products, Ltd., Vancouver
British Columbia Lbr. Mfrs. Assn., Vancouver
Canadian Forest Products Limited, New Westminster, B. C.
Dominion Electrohome Industries, Ltd., Kitchener, Ont.
Knight Mfg. & Lbr. Co. Ltd., Meaford, Ont.
MacMillan & Bloedel Ltd., Nanaimo, B. C.
A. S. Nicholson & Son, Ltd., Burlington, Ont.

THE MAN WITH ANSWERS.

FOR YOUR AUTOMATION AND MATERIALS HANDLING

TO BOOST PRODUCTION . . .

CUT LABOR COSTS!



Walters Automatic Materials—Flow Systems replace expensive labor with precision machinery . . . costs drop fast! Walters offers top engineering and plant layout "know-how", plus over 28 years EXCLUSIVE woodworking experience.

YOUR PROBLEM IS DIFFERENT

That's why it's best to let the Walters representative study your problem with you. He has the experience, the facilities . . . and the *answers!*

- Cable Lumber Lifts
- Cable Tilt Lifts
- Cut-off Saw Tables
- Cut-off Saw Tailboys
- Facer Feeders
- Planer Feeders
- Edge-Jointer Feeders
- Edge-Jointer Return Feeders
- Cross-belt Conveyors
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- Sorting Conveyors
- Powered Roller Conveyors
- Floor-to-floor lifts and Conveyors
- Waste Conveyors
- Moulder Stock Returns
- Slat Conveyors
- Cross-chain Conveyors
- Rip-saw Tailboys
- Rotary Turntables
- Hot-plate Press Loaders
- Automatic Chopping Saws
- Panel Sizing Saws
- Lumber Yard Transfers
- Dead Roll Conveyors
- Powered Curves—Roller and Chain

SPECIAL HANDLING EQUIPMENT—ENGINEERED TO YOUR SPECIFICATIONS

WALTERS W MFG. CO. P.O. BOX 498 PHONE 2203 MORRISTOWN, TENN.

FPRS NEWS-DIGEST

Volume VI OCTOBER, 1956 Number 10

Particle Board Pilot Plant Opening at Teco

The fully equipped particle board pilot plant being constructed at Timber Engineering Co. laboratory, Washington, D. C., will go into operation in early November, according to N. V. Poletika, director of research.

Poletika reports that the pilot plant is designed for the development of all kinds of platen-type wood particle boards from flakes, shavings, splinters, and similar wood residues. Special custom-built equipment will enable application of advanced techniques to production methods and raw materials, from particle preparation to hot pressing of the boards.

A special press will produce 3- by 6-foot boards under pressures up to 500 psi and at temperatures up to 600° F. Higher pressures can be obtained by reduction of board area, and any thickness up to 1½ inches can be produced.

The new facilities will also enable Teco to evaluate all types of wood particle boards and their raw materials, manufacturing processes, end uses, and markets. Users and manufacturers of particle board will be able to use the facilities in determining the type of board best suited for their requirements.

Eddy Succeeds Kroehler as President of NAFM

N. A. Eddy of Habitant Shops, Inc., Bay City, Mich., was elected president of the National Association of Furniture Manufacturers at the recent annual convention in Chicago. He succeeds Kenneth Kroehler, vice-president of Kroehler Manufacturing Co.

Current economic trends and their effect on future prospects for the furniture industry were analyzed at the opening business session. Other speakers discussed marketing problems, and new developments in furniture production techniques. Color control and other finishing problems were discussed by a panel in a special session co-sponsored by the National Paint, Varnish & Lacquer Assoc.

A total of 142 exhibitors filled the 2nd Supply, Equipment and Fabric Fair held in conjunction with the convention (see photos at right). Products displayed included saws, glues, machinery, and surfacings.

Birn and Marian Among Furniture Convention Speakers

Management problems applying specifically to the furniture industry will be discussed by Serge A. Birn, head of a firm of consulting management engineers, at the annual convention of Furniture Manufacturers of Southern California. The convention will be held Oct. 30–Nov. 1 at the Shrine Exposition Hall, Los Angeles, in conjunction with the first Western Furniture Supply Show.

Also scheduled to address the convention is Dr. J. E. Marian, Swedish wood authority who recently joined the California Forest Products Laboratory staff. He will talk on general conditions in the Swedish furniture industry and on gluing and finishing.

Officers of the association for 1957

IMPORTANT FPRS DATES

Fall 1956: Carolinas–Chesapeake Section Annual Meeting, Pinehurst, N. C.

Oct. 29–31: Mid-South Section Annual Meeting, Laurel, Miss.

Nov. 8–9: Great Lakes Section Annual Meeting, Rowe Hotel, Grand Rapids, Mich.

Nov. 15–16: Ohio Valley Section Annual Meeting, Kentucky Hotel, Louisville, Ky.

Dec. 7–8: Florida–Georgia–Alabama Section Annual Meeting, Athens, Ga.

March 7–8, 1957: Eastern Canadian Section Annual Meeting, Queens Hotel, Montreal, Quebec.

June 24–28, 1957: Eleventh National Meeting, Buffalo, N. Y.

Exhibits at NAFM Fair

National Adhesives—Dependable Machine Co.

Deluxe Saw and Tool Co.

Fiberesin Plastics Co.

The Lane Company

Decar Plastics Corp.

WOOD CHEMISTRY and its industrial applications were part of training given 1956 NLMA scholarship winners during their ten weeks of study at Timber Engineering Co. laboratory. The four trainees, shown with Dr. Matthew Sciascia, Teco's senior chemist, are: R. A. Hann, U. of Michigan; D. R. Prestemon, Iowa State College; A. E. Lund, Duke University; and M. H. Stehman, Penn State University.

NEW ADHESIVE AND SYNTHETIC RESIN PLANT of American–Marietta Co. of Canada, Ltd., now being erected at Edmonton, Alberta, is shown in above artist's sketch. Phenol-formaldehyde and urea-formaldehyde will be produced in the plant, scheduled for operation late this year.

will be installed Nov. 2–4 at the Sands Hotel, Las Vegas, Nevada. A board of directors meeting and social program in Las Vegas will conclude the two-part, week-long convention.

Materials, equipment, supplies, and services will be displayed at the Supply Show, according to Eddy S. Feldman, Executive Secretary. The Pacific Southwest Section of FPRS is planning an exhibit of FPRS services.

Furniture Manufacturers Attend Gluing Forum

Key personnel from furniture manufacturing plants in North Carolina attended a "Forum on Modern Gluing Techniques" recently in Hickory, N. C. The meeting was sponsored by Berthelsen Engineering Works, Joliet, Ill., and their southeastern representatives, Garrison Machinery Co., Statesville, N. C.

Production techniques for manufacturing lumber core panels, thin plywood skins, panel-on-frame assemblies, and particle board were discussed by E. F. Steck, Berthelsen Vice-President. Other speakers were K. I. Winther, Berthelsen President, and R. C. Garrison, President of the Statesville firm.

Exhibited were samples of solid core construction, hollow core construction, plastic overlays, particle board assemblies, wood-metal laminates, honeycomb core construction, and others. The 80-man group also observed various gluing operations at Century Furniture Co. in Hickory.

Crossett Co. Utilizing Low Grades, Mill Wastes

Two more steps have been taken toward the Crossett Company's goal of complete utilization of each tree harvested. Recently the firm opened a new paper mill which provides a means of utilizing hardwoods which previously had limited markets. The process reportedly bids to revolutionize papermaking and offers new opportunities for the region's forest resources.

New equipment has been installed at the firm's flooring mill to manufacture paper roll plugs from shavings and scraps of wood. Waste is taken from the flooring machines and ground into fine sawdust-size particles. The material is mixed with glue, molded under pressure and cured for 12 minutes at 300°. The Crossett Co. is the first U. S. firm to purchase and operate one of the machines, manufactured by Chipcraft, Inc., Morristown, Tenn.

Discontinuance of Two Adhesive Grades Announced

Announcement of discontinuance of the manufacture of Uformite 435 and Uformite 400 has been made by Rohm & Haas Co., Philadelphia, Pa. The firm intends to continue in the field of synthetic adhesives for the woodworking and paper industries, and will supply Uformite powders, Tego glue film, Amberlite adhesive resins, and technical service in connection with these products.

Machinery Manufacturers Launch Action Program

The newly formed advertising committee of the Woodworking Machinery Manufacturers Association met in Chicago recently to formalize a "Program of Action" authorized at the Association's board meeting last April. Objectives of the committee are to call attention to the fact that progress in the woodworking industry has demanded new machines of greater precision and faster production. Woodworking machinery manufacturers, who have long recognized this demand, are providing precision equipment built to machine tool standards.

Leslie H. Geddes, chairman of the advertising committee, stated that "The full force of the resources of the Woodworking Machinery Manufacturers Association including engineering, research, plant and production facilities representing a total investment of over $150 million has been brought to bear to help solve the problems of woodworking manufacturers all over the nation. Modern machinery will help remove many of the headaches that these people face—in production speed, in profit, in employee relations, in turning out a better product at a competitive price."

Third Award of Merit Contest Winners Announced

Pacific Lumber Co. won first prize as the lumber manufacturer who had done most in 1955 to promote proper use of lumber in competition with other materials in the Third Annual Award of Merit contest sponsored by Wood Working Digest magazine. The redwood producing firm has won the award twice in the past three years.

First place among lumber, dimension stock, and veneer and plywood associations was won by the Hardwood Plywood Institute, Chicago. Architectural Woodwork Institute received award for finished wood products associations and a fourth award was granted to Consolidated Machinery & Supply Co., Ltd.

Receiving honorable mention citations were: West Coast Lumbermen's Assoc., Gulf Enterprises, National Wood Pallet Manufacturers Assoc., Laity Manufacturing Co., The Borden Co., and State University of New York College of Forestry.

Lumber Production Declines

National production of lumber totaled 3.537 billion board feet during August, according to estimates of NLMA. The month's output was 15 per cent above July but 3 per cent less than the same month in 1955.

New orders in August were up 7 per cent over the previous month but were 1 per cent below August 1955.

For the first eight months this year, production of 25.446 billion board feet was 3 per cent below the same period last year. Shipments were 1 per cent less and new orders 2 per cent less than the 1956 output.

SOCIETY NEWS

1957 National Meeting Committee Announces Preliminary Plans

Committee assignments and preliminary plans for FPRS 1957 National Meeting were announced by General Chairman Charles R. Lockard following a two-day meeting in Buffalo last month. The meeting will be held in Buffalo June 24–28, 1957.

All technical sessions and the Suppliers Table Top Exhibits and Show will be held at the Hotel Statler. Special attention is being paid to developing interesting programs for ladies and children attending. Unusual tours are planned for all, including a trip to Niagara Falls and a cruise on Lake Erie.

Plans for the technical program are still in the formative stage but Russell C. Deckert, chairman of the Table Top Exhibits and Show, is already receiving reservations for technical exhibits. These will occupy the Exhibition Hall, Georgian Room, and the New York Room, all on the mezzanine floor adjacent to the meeting rooms.

Exhibits will be limited to literature, movies, scale models (operational or non-operational), slides, and materials or equipment that can be shown on a 2 by 4-foot table. Facilities are not available for display of heavy equipment. Firms interested in reserving space for an exhibit should contact R. C. Deckert, State University College of Forestry, Syracuse 10, N. Y.

1957 National Meeting Paper Offers Now Being Accepted

Offers of papers for presentation at the FPRS National Meeting in Buffalo June 24–28, 1957, are now being considered. Any person desiring to present a paper at the meeting is invited to submit an offer by December 15, 1956.

Titles and a brief summary of the potential paper should be directed to Technical Program Chairman Frank H. Kaufert, Institute of Agriculture, School of Forestry, University of Minnesota, St. Paul 1, Minn.; the FPRS Executive Office; or to Subject Matter Division Chairmen. Names and addresses of the latter men appear on page 102–A–106–A of this issue.

The summary should clearly state the intended scope of the paper and indicate features of the work that will, in the author's opinion, justify its inclusion on the National Meeting program. Details for submitting the complete paper and related information will be sent authors upon acceptance of their paper.

FPRS 1957 NATIONAL MEETING COMMITTEE met recently in Buffalo with President Ralph H. Bescher to make preliminary plans for the meeting, to be held June 24–28. Committee members shown above are, seated: George Fahlstrom, Frank T. Parrish, J. D. Batson, General Chairman C. R. Lockard, P. H. Graham, Don Saunders; standing; Executive Secretary F. J. Rovsek, E. Dent Lackey, Leonard Cumming, R. C. Gill, A. T. Howse, Dar Ellis, E. A. Anderson, R. C. Deckert. All committee chairmen are listed on page 100–A.

Mid-South Section Plans Annual Meeting in Laurel

Plans are complete for the annual meeting of the Mid-South Section to be held October 29 and 30 at Laurel, Miss., according to Chairman John E. Wells. FPRS President Ralph H. Bescher will attend the meeting.

The technical program will include papers on waste utilization, sawmilling, log grades, particle board and hardboard manufacture. Several plant tours are also on the agenda, as well as a social program for members and their wives.

Great Lakes Section Schedules Fall Meeting in Grand Rapids

Program plans for the fall meeting of the Great Lakes Section were discussed at a meeting of section officers Sept. 25 in East Lansing, Mich. The fall meeting is scheduled Nov. 8 and 9 at the Rowe Hotel, Grand Rapids.

L. J. Markwardt, Assistant Director, U. S. Forest Products Laboratory, will be principal dinner speaker Nov. 8. He will discuss "Highlights of Progress in Forest Products Research."

The technical program will include papers by John LeFerve, I.B.M.; Arthur Bruce, E. L. Bruce Co.; Julius Adams, Haskelite Manufacturing Corp.; and a representative of Dominion Shuttle Co. Papers are also scheduled on the human relations side of automation and prefabricated house manufacturing.

Technical sessions are scheduled both mornings, to be followed by afternoon plant tours. On November 8, the group will tour the high pressure laminate section of American Seating Co. The next day they will visit Imperial Furniture Co. and Haskelite Manufacturing Corp.

See pages 107-A–111-A for New Product News and New Publications

Northern California Section Meets in Eureka and Reno

A tour of the Hammond Lumber Co. operation at Samoa, Calif. was a feature of the Northern California Section meeting Sept. 14. Special interest was shown in the glue department, where work is in progress to develop an electronic gluing process for better utilization of low-grade redwood lumber.

Willard E. Pratt, California Redwood Assoc., was principal speaker following a dinner at the Eureka Inn. He discussed "Estimation of Moisture Content During the Drying Process."

A contribution of $150 to the Executive Office Building Fund was presented by the Section to Regional Board Member Raymond H. Berry at a meeting Sept. 28 in Reno, Nevada. Automation in the Planing Mill was the topic of Bill McCudden, Research Engineer of Diamond Match Co., featured speaker at the dinner meeting in Mapes Hotel. A tour of Vaughn Millwork Co. preceded the dinner.

Stern Addresses Pacific Southwest Section Meeting

"Improved Wood Products with Threaded Nails" was the subject of Prof. E. G. Stern, Virginia Polytechnic Institute, Blacksburg, at a meeting of the Pacific Southwest Section Sept. 17. The dinner meeting, held at Swally's Key Club, Los Angeles, was attended by FPRS President Ralph H. Bescher.

SHORT COURSES

North Carolina State College Schedules Kiln Drying Course

Latest techniques in kiln drying lumber and control of moisture content will be demonstrated in a course at North Carolina State College, Raleigh, Nov. 27–Dec. 1, according to Dean R. J. Preston of the School of Forestry. Moore Dry Kiln Co. and Redman Engineering Service, representing Standard Dry Kiln Co., are cooperating with the College's Extension Division in conducting the course.

Raymond C. Rietz, in charge of drying research at the U. S. Forest Products Laboratory, will assist in the instruction. Others on the teaching staff are Profs. J. S. Bethel, R. M. Carter, and G. K. Slodum, and Walton R. Smith of Southeastern Forest Experiment Station, Asheville, N. C.

Emphasis will be given to reducing both degrade and drying time, Dean Preston stated. Registrants will operate the school's dry kiln.

Registration will be limited to 25 persons, with the enrollment fee set at $50. Reservations and additional information may be obtained from Prof. Roy M. Carter, School of Forestry, N. C. State College, Raleigh.

New Prefabricated Kiln Will Be Operated During Carbondale Course

Instruction in modern dry kiln operation will be given in a course Oct. 29–Nov. 3 by the Division of Technical and Adult Education, Southern Illinois University, Carbondale. The U. S. Forest Products Laboratory and Carbondale Forest Research Center will cooperate in conducting the course at the Wood Products Pilot Plant on the Southern Acres Campus.

The course will help train new kiln operators and also present new drying information to experienced operators and management. Registrants will operate the new prefabricated dry kiln recently installed by the U. S. Forest Service and University at the pilot plant.

Instruction will be given by E. F. Rasmussen, engineer at the U. S. laboratory, and W. W. Rice, superintendent of the Wood Products Pilot Plant. Registration will be limited to 25 persons.

California Laboratory Announces Kiln Operation Short Course

A course in dry kiln operation will be given at the University of California Forest Products Laboratory, Richmond, December 10–15, announces Director Fred E. Dickinson. Cooperating in conducting the course will be the U. S. Forest Products Laboratory and the California Forest and Range Experiment Station.

The laboratory's newly completed dry kiln will be used in the course, which will consist of lectures and demonstrations on dry kiln mechanics, kiln operation, quality control, wood moisture relations, and kiln schedules.

Enrollment fee of $75 will be charged for the course, open to anyone interested in kiln operation. Inquiries for further information should be sent to University Extension, University of California, Berkeley 4.

EMPLOYMENT SERVICE

Positions Offered

No. E 241—Sales of glued laminated structural members. Must be willing to spend several months in engineering and/or estimating dept. to learn product and services. Sales are made through promotion to architects & engineers. Position requires transfer to various company offices for permanent assignment. Forest products degree or forestry training with engineering and/or construction background required. (Oct.)

No. E 244—West Coast plywood company producing interior and exterior Douglas-fir, also hardwood panels, seeks experienced superintendent. (Oct.)

No. E 245—Experienced foreman versed in all mill, assembly and finishing operations for free standing wood store fixture production. Successful, growing factory now employing 60. Pleasant working conditions, congenial people, beautiful community. Ideal location hunters, fishermen and hay fever sufferers. Write Freedman Artcraft Engineering Corp., Charlevoix, Mich. (Oct.)

No. E 251—Pacific Northwest laboratory serving lumber industry seeks wood chemist for fundamental and applied research. (Nov.)

No. E 253—Young man with 10 years' sales and manufacturing management experience desires to form high quality furniture manufacturing company. Seeks production man to assume manufacturing responsibility and be co-investor. Fine opportunity for strong production man to become an owner. (Nov.)

Employment Wanted

No. 368—Forest Management, Sept. Graduate, M.S. Colorado A & M, B.S. Louisiana State. Graduate work has included study of marketing systems for Colorado forest products. Age 26, single. (Oct.)

No. 369—Management position in hardboard or particle board industry desired. Six years experience in wood processing, control, research, development, and sales in hardboard and chipcore industry. B.A., major Chemistry. Age 32. Will locate any area. (Oct.)

No. 385—Young (36) production executive, experienced in plant management, development work and engineering with major western plywood and flush door companies seeks position with promise for the future. (Nov.)

No. 386—B. S. Wood Technology graduate of Purdue University with eight years experience in lumber business from handling and tallying to buying and selling seeks position, preferably in Chicago or Midwest. Has kept full set of books including payroll and taxes. Age 31, married. (Nov.)

Opportunities

WITH THE DEVELOPMENT DEPARTMENT OF A LEADING PRODUCER OF WOOD INSULATION PRODUCTS—BOTH BLANKET AND BOARD—LOCATED IN NORTH-CENTRAL U. S.

Positions Offered:

1. **ORGANIC CHEMIST** with good background in pulp and paper science and knowledge of high polymers for applied research in basic problems of processes and products involving wood fiber, textile fiber, structural, heat and sound insulating building materials and packaging materials. Advanced degree in chemistry with one or two years experience desirable. Salary commensurate with qualifications and experience.

2. **RESEARCH PHYSICIST** or research engineer with MS training or equivalent having background and interest applicable to fundamental mechanical properties of materials, heat transfer, moisture transfer or sound absorption and sound isolation characteristics of fibrous and porous materials. One or two years industrial experience desirable. Salary commensurate with qualifications and experience.

3. **DESIGN & DEVELOPMENT . . .** Personable, market-minded man for design and development of building products for structural, insulating and decorative uses. Varied and expanding program will include travel, consumer contacts, and liaison with Sales. College graduate with technical background and 5–10 years experience is preferred. Salary commensurate with qualifications and experience.

4. **CHEMICAL OR MECHANICAL ENGINEER,** top quality, BS or MS, with leadership qualities for process engineering phases of development work involving use of wood fiber and textile fibers as basic raw materials of structural, insulating and cushioning fiber products. Experience of 5–10 years required which has included supervision of others in carrying projects from initial stages through to commercialization. Initiative, drive, thoroughness and understanding of basic engineering fundamentals are important qualifications. Salary commensurate with qualifications and experience.

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Madison 5, Wisconsin

Tenth National Meeting Largest in FPRS History

REGISTRATIONS for plant tours were signed up by L. Gaby and B. M. Witherow, left. At right are C. E. Lehman, High Point, N. C., and R. C. Gill, Gowanda, N. Y.

HOST HOUR on Sunday, June 3, kicked off full week of technical sessions and outstanding program of entertainment. At right are John Reno, J. B. Huffman, Lou Gaby, and Mrs. W. R. Smith.

THE FPRS' TENTH NATIONAL MEETING June 3–8 at Asheville, N. C., was a marked success from a number of viewpoints.

It represented the first table-top and light apparatus exhibit held under the direct auspices of the Society since 1953. More than 70 exhibits filled the Asheville City Auditorium to capacity and attracted an unofficial estimated 1,000 attendance.

It was also the largest technical meeting held to date with 14 sessions and 12 subject matter committee meetings. These were conducted in the City Auditorium, and the Battery Park and George Vanderbilt Hotels.

A new high in local news coverage was reached as the two Asheville papers, the Citizen and the Times, and the local radio and television stations covered the meeting throughout the six-day period.

Attendance Tops 800

Official attendance at the Tenth National Meeting was 808, of which 162 were ladies. Of the men, 406 were members and 240 non-members. The total registration was the second highest for any meeting to date, exceeded only by the 863 figure for Grand Rapids in 1954.

Registration got underway at 2:30 P.M. on Sunday. The registration fee was $7.50 for members and $10.00 for non-members. It included abstracts of the technical papers, admission to sessions, committee meetings, suppliers exhibit, Paul Bunyan barbecue, and plant tours.

The National Meeting was officially opened at 9 A.M. Monday, June 4, as President Moss B. Christian welcomed the registrants from the U. S., Canada, and overseas.

The social activities began with the traditional Host Hour on Sunday evening, sponsored by the Carolinas–Chesapeake Section. This event, held in the East Ballroom of the George Vanderbilt Hotel, attracted several hundred guests.

On Monday evening 300 guests attended the command performance of a play, "Tight Britches" at the William Randolph School auditorium. The play is an authentic drama of Smoky Mountain life enacted by local actors. It is a sociological study of the three predominating strata of mountain society and what happens when they clash.

Exhibitors' Day

Tuesday, June 5, was billed as "Exhibitors' Day" and no technical sessions were held on that morning to enable all registrants to visit the exhibits in the auditorium.

Among the booths was the FPRS Employment Placement Service which was active daily throughout the meeting. For the third consecutive year, this informal employment service, which assists persons seeking positions as well as employers who seek personnel, was under the capable direction of Prof. Newell A. Norton, Penn State University.

Christian, Truax Honored at Official Luncheon

The annual business meeting with 60 in attendance was held at 11:00 A.M. followed by the Official Luncheon in the City Auditorium. A record crowd of almost 500 men and ladies witnessed retiring President Moss B. Christian being presented with a deer rifle and telescopic sight in appreciation of his six years of service to the Society. The presentation was made by Ralph H. Bescher, incoming President.

President–Elect Frank H. Kaufert presented a citation on behalf of the Society to Dr. Thomas R. Truax, Chief, Division of Timber Processing U. S. Forest Products Laboratory, "for your years of service to the forest products industries through individual research and leadership of research, for your contributions to the development of woodworking adhesives and the science of gluing, for your cooperation with the industries in solving many glued-wood construction problems, and for being just Tom Truax to a host of friends in the forest products industries and Forest Products Research Society, we wish to present you with this token of our high regard, affection, and esteem. With it go our sincere best wishes and a hearty 'Thanks Tom' for all of your contributions and helpfulness. The in-

SESSION I—QUALITY CONTROL

SESSION II—WOOD PRESERVATION

SESSION III—WOOD PRESERVATION

SESSION IV—MARKETING

SESSION V—GLUES AND GLUING

SESSION VI—GLUES AND GLUING

SESSION VII—WOOD DRYING

SESSION VIII—CHEMICAL UTILIZATION

SESSION IX—WOOD MACHINING

SESSION X—LOGGING AND MILLING

SESSION XI—WOOD COMPOSITION BOARD

SESSION XII—WOOD FINISHING

SERVICE TO INDUSTRY of T. R. Truax, left, was recognized with gift presented from Society by President-Elect F. H. Kaufert, right.

BETWEEN-SESSIONS breaks were taken by FPRS registrants and wives in front of two of host hotels, Battery Park at left, George Vanderbilt at right.

dustry you have served for over 40 years and your many friends throughout the country appreciate your contributions."

Guest Speaker Robertson

The principal speaker at the Official Luncheon was Reuben B. Robertson, Sr., President and Chairman of the Board of Champion Paper and Fibre Co. Mr. Robertson, in his inspiring address, explored the limitless potential of research in the forest products industries (see Guest Editorial, page 51–A).

7th Annual Wood Awards

The seventh annual Wood and Wood Products Awards were presented by Jack Koellisch, editor and manager of WOOD AND WOOD PRODUCTS magazine in behalf of Vance Publishing Co. Mr. Koellisch was introduced by FPRS Industry-Education Division Chairman Alexis J. Panshin, Michigan State University. This year for the first time, the two awards were made on the basis of the best papers submitted by students in graduate programs of wood technology.

First award of $350 and certificate was made to Selwyn Fox, University of Toronto, for his paper, "An Investigation into the Effects of Certain Variables in Scarf-Jointed Timber Laminations. (See page 428.) The second award of $150 and certificate was made to Norman C. Higgins for his paper based on studies made at Penn State University on "The Effect of Species on the Relative Humidity-Equilibrium Moisture Content Relationship."

Other entrants in the competition included: James Oberg, University of Minnesota, "The Nature and Significance of Discoloration in Aspen"; Robert H. McAlister, University of Idaho, "Specific Gravity Variation in Douglas–fir of the Inland Empire Type"; Harold E. Wahlgren, Iowa State, "Effect of Tension Wood on the Longitudinal Shrinkage of Eastern Cottonwood"; Paul A. Anderson, Yale University, "A New Look at Fiber Saturation Point"; Howard A. Spalt, Yale University, "Development of Precision Apparatus for Measuring the Sorption of Water Vapor by Wood"; D. F. Arseneau, University of Laval, "The Dimensional Stabilization of Wood"; Robert Chrismer, N. C. State, "A Method of Determining Drying Schedules for Veneer"; Warren S. Thompson, Alabama Polytechnic Institute, "Evaluation of Three Oil-Type Wood Preservatives by a Modification of the Soil-Block Method"; Robert W. Davidson, State University of New York, "Impact Force-Deflection Diagrams for the FPL Toughness Test"; and Mel A. Barkan, Massachusetts Institute of Technology, "Partially Continuous Wooden Beams".

Past Presidents' Dinner

Tuesday evening was left open for informal dinners and visits of the members and guests. One such event was the traditional Past Presidents' Dinner held at the Grove Park Inn. Among the past presidents present were: George Garratt, Yale Forestry School; E. G. Locke, U. S. Forest Products Laboratory; J. F. Hamilton, Michigan College of Mining & Technology; Roy M. Carter, N. C. State College; L. J. Carr, L. J. Carr & Co.; and Moss B. Christian. Other former presidents sent wires or letters indicating that due to business reasons they were unable to be present at this year's affair.

Paul Bunyan Barbecue

The social highpoint of the meeting was the all-afternoon and evening 130-mile bus tour of the Cherokee Indian Reservation in the Great Smoky Mt. National Park and the Paul Bunyan southern-style barbecue at Heintooga Bald Overlook, a picnic area at 5,000 feet elevation in the mountains. Over 600 persons boarded some 20 buses leaving at intervals during Wednesday afternoon, June 6, for the tour.

WOOD AWARD winners were S. P. Fox, left, and N. C. Higgins, right. Seated center is J. F. Koellisch, Wood and Wood products magazine; standing: H. O. Fleischer, Chairman of Judges; A. J. Panshin, Chairman of Industry–Education Committee.

SESSION XIII—PACKAGING

SESSION XIV—VENEER AND PLYWOOD

3

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PRESSURE-CREOSOTING with BARRETT CREOSOTE

will bring you more sales this year!

1 **Powerful Barrett Promotions** like these are creating a record demand for pressure-creosoted poles, posts and lumber. Hard-hitting advertising in leading farm magazines will reach over 4,300,000 farmers this building season. Barrett has already answered thousands of inquiries with free pamphlets on how to use pressure-creosoted wood on the farm. The retail lumberman, too, is pre-sold on stocking pressure-creosoted products through Barrett advertising in "Building Supply News" and "American Lumberman."

2 **Vast NEW markets** are now opening for pressure-creosoted poles and lumber. Bunker silos, pole-type barns and other farm buildings are gaining rapidly in popularity—greatly increasing the need for pressure-creosoted wood. Barrett promotion is designed to stimulate interest in these low-cost structures.

3 **Creosote is the ONLY time-proved wood preservative.** Farmers *know* from experience that pressure-creosoted poles and lumber give 3 to 5 times the service life of untreated wood. They know that creosote gives surest protection. It's the wood preservative that's in greatest demand.

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Paul Bunyan Sponsors

The wood industry suppliers who were hosts to registrants and their families included:

American Cyanamid Co., Charlotte, N. C.
American Cyanamid Co., New York
American Manufacturing Co., Tacoma, Wash.
Auto-Soler Co., Atlanta, Ga.
Bauer Bros. Co., Springfield, Ohio
Behr-Manning Co., Troy, N. Y.
Black Brothers Co., Inc., Mendota, Ill.
The Borden Co., New York
Carborundum Co., Niagara Falls, N. Y.
Catalin Corp. of America, New York
Chapman Chemical Co., Memphis, Tenn.
Chipcraft, Inc., Morristown, Tenn.
Coe Manufacturing Co., Painesville, Ohio
Peter Cooper Corp., Gowanda, N. Y.
DeLuxe Saw & Tool Co., Louisville, Ky.
Henry Disston Div., H. K. Porter Co., Philadelphia, Pa.
Hitchcock Publishing Co., Wheaton, Ill.
Jenkins Woodworking Machinery Div., Curt G. Joa, Inc., Sheboygan Falls, Wis.
Kennametal, Inc., Latrobe, Pa.

(Continued on page 65-A)

PAUL BUNYAN BARBECUE sponsored by industry suppliers (listed on banner below) was enjoyed by more than 700 persons.

for Duty for Beauty

for the *Best* in laminates look to

Parkwood

HI-DEN (Parkwood trade name for densified wood) Made from carefully selected wood veneers, impregnated with phenolic resin, and compressed and cured under high pressure and temperature. Tough, dense, moisture- and oil-resistant, dimensionally stable, it is widely used in products ranging from industrial forming tools to architectural hardware, knife handles and conveyor systems.

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Beautiful, laminated plastic panels in a wide range of decorator colors, exclusive patterns and superb wood grain reproductions . . . for use in furniture, counter tops, walls, wainscoting and many other applications.

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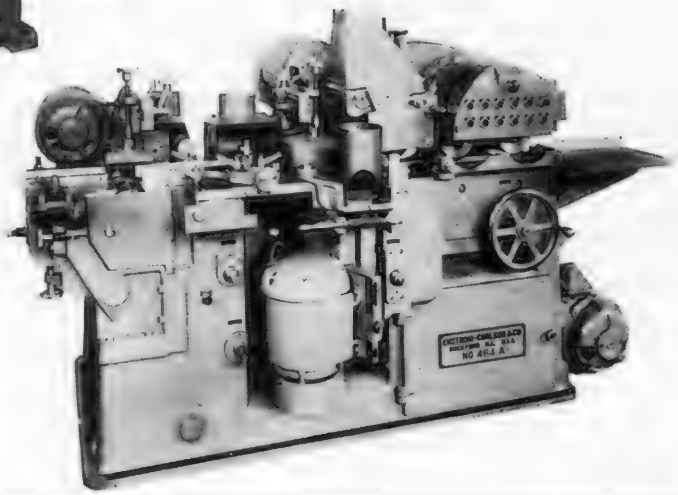
A pneumatically activated saw of a new and tried design, for both right and left-hand operations as selected. Direct drive 7½ h.p. motor, 18" maximum saw capacity, for 5" thickness in material. Cut-off movement adjustable to four positions by dial setting, maximum 21". Vertical adjustment of saw motor, 3".

MODEL MM RIP SAW

Formerly known as Marion Rip Saw, the result of many years of experience. Hundreds shipped to the woodworking industry where, in comparison alongside competitive machines, they have been termed "The Best Glue Line Rip Saw". Equipped with 10, 15, or 20 h.p. saw motor, and 3 h.p. feed motor. Large ripping capacity, many useful features, four feeds (also Model M with 8 feeds).

HI-SPEED MOULDERS

No other moulder, regardless of price, provides all the advantages of ECCo Moulders. ECCo's distinctive spindle design permits speeds of 3600, 4800, 5400, 6000, or 7200 r.p.m. **without a frequency changer!** Any or all cutterheads operate at any of these speeds **simultaneously.** All models have automatic spindle brakes . . . infinitely variable feed rates from 25 to 225 feet per minute **without stopping the machine,** cutterhead dusthoods, easily accessible cutterhead areas for quick set-ups. Available in 6", 8", or 12" capacities.



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Over 70 Firms Show Wares at Suppliers Exhibit

MORE THAN 70 FIRMS and educational organizations completely occupied the 95-booth FPRS Suppliers' Exhibit held concurrently with the Tenth National Meeting. The exhibits filled 14,000 square feet on the ground floor of the Asheville City Auditorium.

The exhibit was open daily from 10:00 A.M. to 4:30 P.M. with the exception of Wednesday, when a majority of the exhibitors and registrants went on the 130-mile trek to the Paul Bunyan Barbecue. Tuesday was declared as official Exhibitors' Day to give registrants ample opportunity to visit with the suppliers.

While there were 646 official meeting registrants who had opportunity to visit the exhibit, it is estimated that several hundred additional persons from nearby manufacturing and lumber operations visited the exhibit, to bring the total attendance in the neighborhood of 1,000.

FPRS 1956 Exhibitors

Both the large registration for the National Meeting and its financial success are attributed to this Suppliers' Exhibit.

A list of the exhibitors along with their principal products follows:

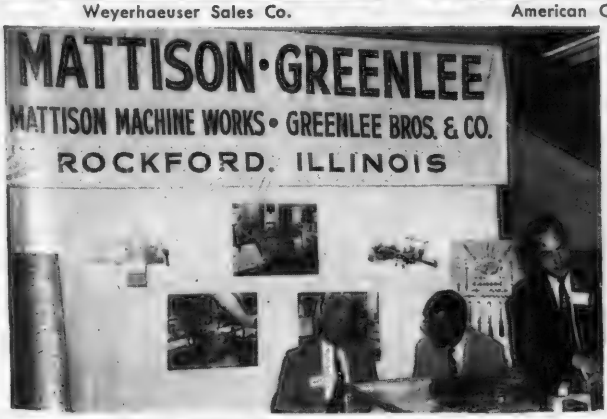
Adamson–United Co., Akron, Ohio—Chipcore Machinery & Engineering
Alabama Polytechnic Institute, Auburn—Education and Research
American Cyanamid Co., Charlotte, N. C.—Adhesives & Resins
The Bahnson Co., Winston–Salem, N. C.—Dehumidifying Equipment
Binks Manufacturing Co., Chicago—Finishing Systems
The Borden Co., New York City—Adhesives
Bramco, Inc., New York City—Chipcore Plants & Engineering
Carboloy Dept., General Electric Co., Detroit—Carbide Tools
Carolina Forest Products Co., Wilmington, N. C.
Catalin Corp of America, Greensboro, N. C.—Adhesives and Resins
Cellu-Products Co., High Point, N. C.—Furniture Padding
Chipcraft, Inc., Morristown, Tenn.—Chipcore Systems
Cleworth Publishing Co., Greenwich, Conn.—Industrial Woodworking magazine
The Dean Co., Chicago—Chipcore
Decar Plastic Corp., Middleton, Wis.—Decorative Laminates
Deluxe Saw & Tool Co., Louisville, Ky.—Carbide Tools
Dependable Machine Co., Greensboro, N. C.—Machinery
Drexel Furniture Co., Drexel, N. C.—Chipcore
Duke University, Durham, N. C.—Education and Research
E. I. duPont de Nemours & Co., Wilmington, Del.—Finishes
Durez Plastics Div., Hooker Electrochemical Co., N. Tonawanda, N. Y.—Resins
Franklin Glue Co., Columbus, Ohio—Adhesives
Guilliet Co., Auxerre, France, Represented in U. S. by Council on Public Relations, New York City—Chippers
Hardwood Corp. of America, Asheville, N. C.—Dimension Lumber
The Heil Co., Milwaukee, Wis.—Chip Drying Systems
R. Hoe & Co., Inc., High Point, N. C.—Carbide Tools
Jenkins Machinery Div., Curt G. Joa, Inc., Sheboygan Falls, Wis.—Woodworking Machinery
Kennametal, Inc., Latrobe, Pa.—Carbide Tools
The Lilly Co., High Point, N. C.—Finishes
Lustrewood Corp., Milford, Conn.—Prefinished Drawer Bottoms
Mall Tool Co., Chicago—Portable Power Tools
Marietta Paint & Color Co., High Point, N. C.—Finishes
Masonite Corp., Chicago—Hardboard Products
W. F. Meyers Co., Bedford, Ind.—Carbide Tools
University of Michigan, Ann Arbor—Education and Research
Michigan State University, East Lansing—Education and Research
Miller–Hofft, Inc., Richmond, Va.—Chipcore Plants & Engineering
Moore Dry Kiln Co., Jacksonville, Fla.—Dry Kilns
National Adhesives, New York City—Adhesives

(Continued on page 71-A)

Weyerhaeuser Sales Co.

American Cyanamid Co.

Dependable Machine Co.



Mattison Machine Works—Greenlee Bros. & Co.

MOORE DRY KILN COMPANY
MOORE CROSS-CIRCULATION LUMBER AIR TIGHT DRYERS
LUMBER STACKERS, UNSTACKERS AND POWER TRANSFER CARS
TO REDUCE COSTS INCREASE PRODUCTION
MOORE
Moore Dry Kiln Co.

Catalin..... RESIN 8666

AN EXCEPTIONAL
Modified
Urea Formaldehyde

GAP FILLING CRAZE RESISTANT ADHESIVE

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Catalin Resin 8666 is a chemically modified, liquid urea formaldehyde adhesive. It yields exceptionally durable, craze resistant, gap filling, moisture resistant bonds. Perfect for assembly and structural wood gluing . . . Resin 8666 is also an excellent adhesive for bonding decorative laminates to plywood, wood cores or hardboards such as "Masonite." Write for samples and technical data.

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Minutes of FPRS Tenth Annual Business Meeting

THE TENTH ANNUAL BUSINESS MEETING of the Forest Products Research Society was called to order by President Moss B. Christian at 1:00 A.M., Tuesday, June 5, 1956, in the East Ballroom of the George Vanderbilt Hotel, Asheville, N. C. Sixty members were in attendance.

1. Minutes of 1955 Business Meeting

The preceding annual business meeting was held in Seattle, Wash., June 28, 1955. The Minutes of this meeting were published in the October, 1955 issue of the FOREST PRODUCTS JOURNAL. L. J. Carr moved, J. S. Bethel seconded that the minutes be approved as published. The motion carried.

2. Annual Report of Executive Secretary for 1955 Fiscal Year

Frank J. Rovsek, Executive Secretary, extended his appreciation to the membership, section, and national officers for their understanding, patience, and cooperation with Executive Office administration. He noted that during the nine-month 1955 fiscal year, membership increased from 2705 on April 1, 1955, to 2816 on December 31, 1955, and subscriptions increased from 85 to 196. The membership comprised 2284 voting and associate, 242 student, 100 company supporting, and 190 overseas members.

Financially, we started with a cash balance of $22,670.15 on April 1, and concluded with $28,698.97 on December 31. Income for this period amounted to $68,589.14; expenses, $62,911.89.

Our Section growth is healthy. Thirteen Sections held 16 separate meetings during these nine months; the first Regional meeting in our history was held at Chicago last November, with three Sections in the North–Central Region joining efforts.

The Executive Secretary stated that on the basis of the Society's strong showing in its first decade of growth, and the experience of similar societies, FPRS is on the threshold of a period of growth that will, in not too many years hence, see it number over 5,000 individuals and companies.

3. Report of Audit Committee

The committee, consisting of Harold L. Mitchell, U. S. Forest Products Laboratory, Madison, Wis., Ralph J. Simonne, J. J. Fitzpatrick Lumber Co., Madison, Wis., and T. Walter Noble, Dexter Plastics Corp., Middleton, Wis., Chairman, with accountants Victor Hobert and Dan Richmond, and the Executive Secretary, met in Madison in May. It examined the records of the Society for the nine-month period, April 1, 1955 through December 31, 1955 (new fiscal year end) and reported that the balance sheet, operating statement, and report of Section finances and comparative statistics is a true summary, and statement of current position, of the financial transactions for the year. (Note: Copy of operating statement was published in the May JOURNAL.)

NEW OFFICERS INSTALLED included President Ralph H. Bescher, right, and President-Elect Frank H. Kaufert.

The committee stated that because of the change in fiscal year period, direct comparison with previous year records would have been difficult except for the cooperation of the auditors and Executive Secretary who prepared comparison summary sheets facilitating comparison.

The committee thanks these gentlemen for their work and cooperation.

4. Report of the Publications Committee

The Publications Committee in its annual report desires to emphasize the outstanding progress made by the FOREST PRODUCTS JOURNAL during the past year. The major development has been the conversion of the JOURNAL to monthly publication. The two special issues are to be maintained. The Annual Review Issue will continue to highlight reports prepared by the Subject Matter Divisions of the Society summarizing the progress made

FPRS SECTION MEETINGS APRIL 1, 1955 TO OCTOBER 1, 1956

Date	Section	Place	Subject
April 11–12, 1955	Midwest	Urbana, Ill.	Forest Products In Today's Homes
April 28–29, 1955	Northeast	Glens Falls, N. Y.	Streamlining Forest Products Technology
May 12–14, 1955	Carolinas–Chesapeake	Wrightsville, N. C.	Waste Utilization
May 12–13, 1955	Fla.–Ga.–Ala.	Savannah, Ga.	Mechanical and Chemical Use of Wood
May 13, 1955	Northern California	San Francisco, Calif.	Veneer and Plywood, Box Lumber, Wood Chemistry
May 13, 1955	Ohio Valley	Louisville, Ky.	Polyvinyl Resin, Forest Management, Economics
June 29, 1955	Pacific Southwest	Los Angeles, Calif.	Chipcore
August 4–6, 1955	Inland Empire	Butte, Montana	Engelmann Spruce, Material Handling, Laminated Structures
Sept. 29–30, 1955	Carolinas–Chesapeake	High Point, N. C.	Furniture, Finishing, Maintenance
Oct. 13–14, 1955	Ohio Valley	Louisville, Ky.	Stanford Report, Seasoning, Chipcore, Utilization
Oct. 20–21, 1955	Northeast	New York, N. Y.	Atomic Age of Wood
Oct. 24–25, 1955	Pacific Northwest	Vancouver, B. C.	Sawmill Operations, Residue Utilization
Oct. 28, 1955	Northern California	Antioch, Calif.	Waste Wood Utilization, New Uses for Paper Overlaid Products
Nov. 7–8, 1955	Mid-South	Memphis, Tenn.	Chemical Seasoning, Sawmill Design and Operation, Utilization of Hardwood Waste, Merchandising
Nov. 15–17, 1955	North Central Region (Midwest, Upper Mississippi Valley, and Great Lakes Sections)	Chicago, Ill.	Stanford Report, Furniture, Plywood, Composition Board, By-Products
Nov. 18–19, 1955	Fla.–Ga.–Ala.	Gainesville, Fla.	Prevention of Decay and Termite Damage in Home Construction
Nov. 30, 1955	Pacific Southwest	Los Angeles, Calif.	Fire Resistant Qualities of Wood
Jan. 12–13, 1956	Inland Empire	Spokane, Wash.	High Speed Wood Lamination
Feb. 6–7, 1956	Pacific Northwest	Longview, Wash.	Production and Use of Veneer and Plywood and Composition Board
March 1–2, 1956	Eastern Canadian	Toronto, Ontario	Furniture Manufacturing and Waste Utilization
April 17, 1956	Pacific Southwest	Los Angeles, Calif.	Facilities of New Forest Products Lab, University of California
April 19–20, 1956	Northeast	Springfield, Mass.	Synthetic Wood Materials
April 26–27, 1956	Great Lakes	Manistee, Mich.	Utilization of Michigan Hardwoods
April 27, 1956	Northern California	San Francisco, Calif.	Chemical Utilization, Waste Utilization
May 2–3, 1956	Midwest	Dubuque, Iowa	Modular System of Home Construction
May 3, 1956	Upper Miss. Valley	Minneapolis, Minn.	Lamination in Construction
May 7–8, 1956	Pacific Northwest	Eugene, Ore.	Pulping and Sawmilling
May 17–18, 1956	Ohio Valley	Jasper, Ind.	New Approaches to Wood Utilization
June 20, 1956	Pacific Southwest	Los Angeles, Calif.	Waste Utilization
June 22, 1956	Mid-South	Silsbee, Texas	Plant Tour of Kirby Co.
Sept. 14, 1956	Northern California	Eureka, Calif.	Electronic Gluing, Seasoning
Sept. 17, 1956	Pacific Southwest	Los Angeles, Calif.	Improved Wood Products With Threaded Nails
Sept. 24–25, 1956	Northwest Region (Inland Empire and Pacific Northwest Sections)	Lewiston, Idaho	Research Trends in Lumber Manufacture, Paperboard, Composition Board, Air Systems for Chip Movement, High Temperature Drying, Direct Fired Dryers
Sept. 28, 1956	Northern California	Reno, Nevada	Automation in the Planing Mill

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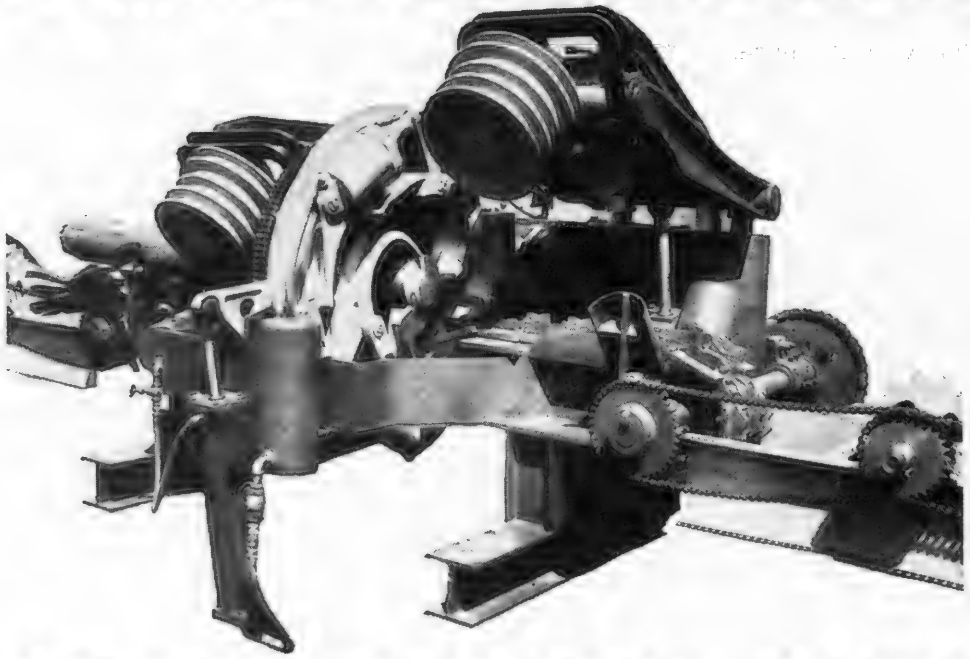

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and the new developments in each Division's field. The Yearbook Issue which highlights the National Meeting will contain a large number of the outstanding papers from that meeting.

Another important milestone was the publication of an accumulative 9-year index.

The JOURNAL will be expanded in 1956 to an estimated 1,046 pages. Even with this expansion, there is a backlog of 185 papers—about equal to the number which will be published during 1956.

The Committee urges that the JOURNAL be emphasized as a primary source of information and that the backlog of papers be kept down—not to exceed six months. To make papers more timely, the Committee urges that more papers be abstracted and the abstracts published. A detailed list of Recommendations has been submitted to the Society President.

The retiring Chairman of the Publications Committee is confident that the JOURNAL will continue to grow under the guidance of the new Publications Committee and its Chairman, and wishes to thank and acknowledge the contributions of his committee. It consisted of: E. A. Behr, Chapman Chemical Co.; Dr. E. A. Anderson, State University of N. Y. College of Forestry; Dr. R. A. Cockrell, University of California School of Forestry; Dr. J. S. Bethel, N. C. State College; J. H. Tigelaar, Haskelite Manufacturing Corp.; R. N. Hammond, Consultant; Dr. A. B. Anderson, University of California School of Forestry; Prof. F. F. Wangaard, Vice-Chairman in charge of abstracts, Yale School of Forestry; M. S. Hudson, Consulting Chemist; and I. H. Isenberg, The Institute of Paper Chemistry.

—E. G. Locke, Chairman

5. Report of Subject Matter Committees

The excellence of the technical sessions at this meeting, the quality of the reviews in the February Review Issue of the FOREST PRODUCTS JOURNAL, and the several added projects of individual committees is evidence that the Subject Matter Committees of the Forest Products Research Society have had a busy and productive year.

Several committees have grown and developed to the point where subcommittees have been formed and are active. The program of one of the committees has developed to the point of considering splitting into two committees. The possibility of establishing a new committee to deal with wood as a structural material has been discussed. This area of wood-use research is touched on by several existing committees, but none deal directly with it.

PUBLICATIONS COMMITTEE meeting was attended by E. G. Locke, F. H. Kaufert, F. F. Wangaard, F. E. Dickinson, B. S. Bryant, E. A. Behr, J. D. Snodgrass.

Since the structural use of wood is still, and no doubt will remain a major use, this proposal should receive serious consideration. Some committees need to be strengthened; their membership should be such that strength is assured, but changes and bringing in new members to assure growth and continued activity is essential.

The functioning of these committees has been and will continue to be largely dependent on their leadership, on the chairmen and their active, contributing members. A year of close association with these committees, their chairmen, and their programs, has impressed me with the amount of work being done, with the interest shown, and progress made. The membership owes a vote of thanks and appreciation to Subject Matter Committee members and special recognition to the chairmen for their many and varied contributions. FPRS members interested in functioning on Subject Matter Committees are urged to contact committee chairmen.

The present Subject Matter Committees and their chairmen are: Wood Machining and Equipment, L. A. Patronsky, Wabash Screen Door Co., Minneapolis, Minn.; Industry–Education, A. J. Panshin, Michigan State University, East Lansing; Packaging, Kenneth W. Kruger, U. S. Forest Products Laboratory, Madison, Wis.; Wood Preservation, Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo.; Marketing, Philip H. W. Creden, Edward Hines Lumber Co., Chicago; Chemical Utilization, Reavis C. Sproull, Philip Morris, Richmond, Va.; Glues and Gluing, Alan A. Marra, University of Michigan, Ann Arbor; Wood Drying, Leif D. Espenas, Oregon Forest Products Laboratory, Corvallis; Logging and Milling, Fred C. Simmons, Northeast Forest Experiment Station, Upper Darby, Pa.; Wood Composition Board, George G. Marra, Washington State Institute of Technology, Pullman; Wood Finishing, E. Sigurd Johnson, North Carolina State College, Raleigh; Quality Control, Charles Latimer, Nickey Bros., Memphis, Tenn.; Veneer and Plywood, H. C. Fleischer, U. S. Forest Products Lab, Madison, Wis.; Employment, Newell Norton, Pennsylvania State University, University Park.

Your Officers and Executive Board recognize the Subject Matter Committees as the backbone of the Society. The Society has been strengthened as the Subject Matter Committees have developed. The future of the Society will be even more directly dependent upon the continued activity and functioning of the present and possibly new committees.

—F. H. Kaufert, Co-ordinator

6. Report of Eleventh National Meeting Committee

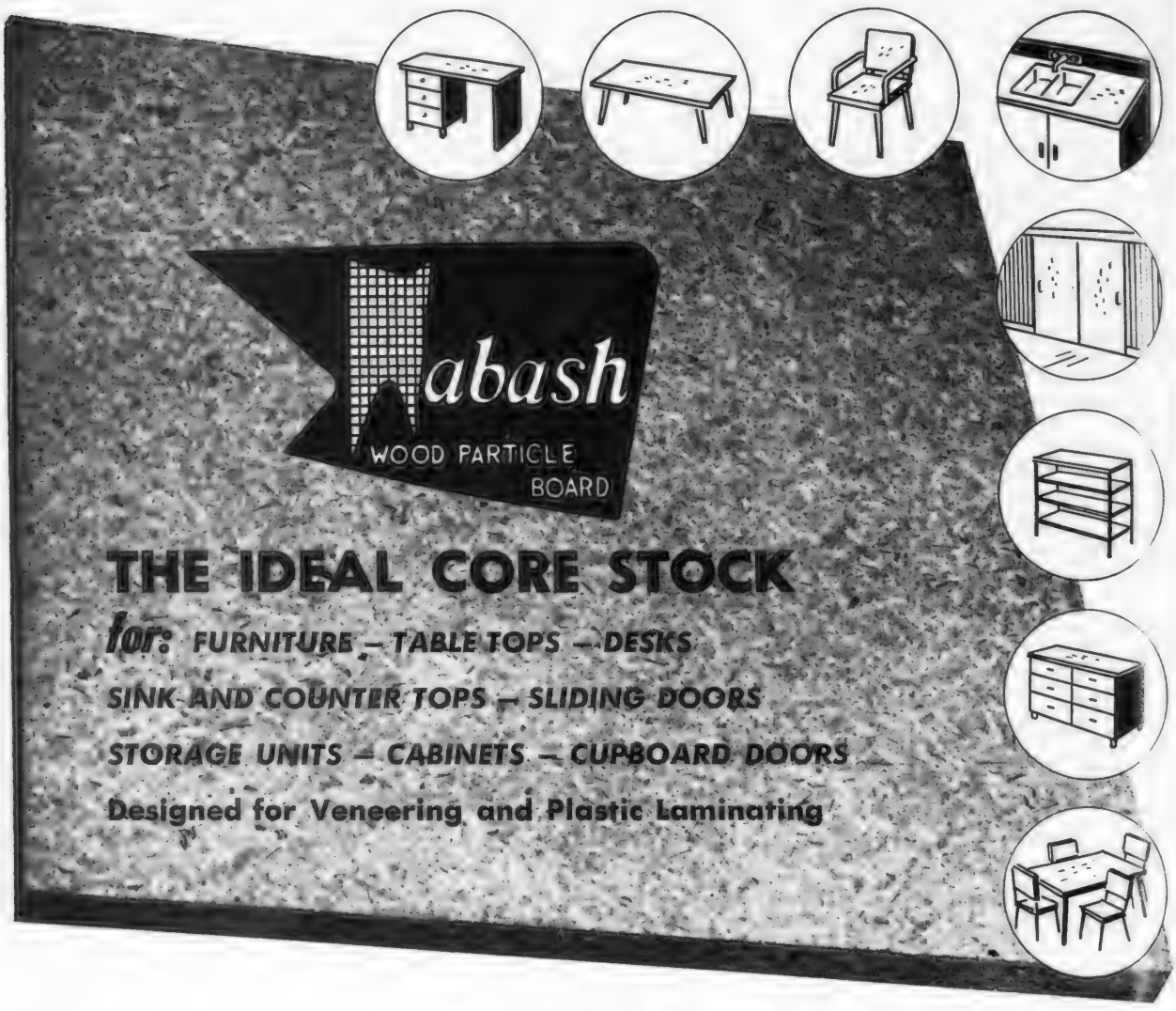
President–Elect Ralph H. Bescher reported on plans for the 1957 meeting to be held in Buffalo, N. Y., June 24–28, 1957. He expressed the regret of the Executive Board that National Meeting Chairman Frank Parrish, Heywood–Wakefield Co., Gardner, Mass., was not able to be present to make this report in person. He announced that due to a growing increase in company responsibilities, Mr. Parrish had tendered his resignation both as Northeast Regional Board Member and as Chairman of the 1957 meeting. He extended the sincere appreciation of the organization to Mr. Parrish for the tremendous job he had done in these and other activities in behalf of FPRS.

Mr. Bescher announced that by Executive Board action, Charles R. Lockard, U. S. Forest Service, Upper Darby, Pa., would succeed Mr. Parrish both to fill the unexpired term as Northeast Regional Board Member and as Chairman of the next National Meeting.

The 1957 National Meeting will incorporate a number of new features. The meeting will open with a general session which the entire registration will attend as a unit, social events will include a visit to Niagara Falls, and a table-top type exhibit will be held.

7. Report of National Membership Committee

It was noted earlier that Frank Parrish, current chairman, had resigned from the Executive Board and attendant committees. The Executive Secretary made a brief report on membership status. He noted that on June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MEMBERSHIP AWARDS presented at meeting are displayed by G. H. Schmidt, National Office employee.

1, 1955, membership stood at 2,789. This increased by June 1, 1956 to 3,040. When we include approximately 200 subscribers, this increases our effective total figure to more than 3,200.

Under the direction of Robert L. Hiller, a special membership drive was conducted during the National Meeting with a goal of 50 new members.

For the second successive year, membership awards in the form of large banners suitable for display at Section meetings were presented to the membership chairmen of the following Sections:

Eastern Canadian Section — First award for greatest percentage gain 1955–56, presented to membership chairman Louis Roy.

Pacific Northwest Section — Second award for greatest numerical gain 1955–56, presented to membership chairman Earl McCarthy.

Inland Empire Section — Third award as runner-up 1955–56, presented to Tony Veazey in behalf of membership chairman H. McKean.

The Secretary outlined national membership plans for the ensuing year. The goal is to have at least one membership man in every state and province of the U. S. and Canada. These state membership chairmen will report directly to the 13 Section membership chairmen. Initially, each of the state men will be asked to submit a list of not less than six local prospects for membership who will be placed on a special list to receive several complimentary copies of the JOURNAL prior to active solicitation. It should be noted that in all cases state membership chairmen are to be approved and appointed by the Section membership chairmen.

8. Report of Resolutions Committee

1. The Society records with deep regret the passing during the past year of the following members: D. C. Everest, H. W. Cowan, Floyd Hart, Charles J. Williams, R. M. Wirka, T. E. Heppenstall, Thomas H. Vaughan, John R. Green, Edward W. Hinkle, Howard E. Page, C. W. Lutton.

Be it resolved that this expression of sympathy to the families and friends of these men be included in the permanent records of this meeting and of the Society.

2. In appreciation of the meritorious services that have been rendered to the Forest Products Research Society during their term of office,

Be it resolved that the gratitude of the Society be extended to all of our outgoing officers including Executive Officers, Regional Board Members and Section Officers.

3. Recognizing that the success of the 10th Annual Meeting of the Society is in large measure due to the foresight, planning and diligence of the Annual Meeting Committees,

Be it resolved that the Society hereby acknowledges its appreciation to the members for their excellent and successful work.

4. In view of the splendid cooperation and services provided by our host hotels in helping to make this Annual Meeting a success,

(Continued on page 69-A)

LEADING MEMBERSHIP SALESMAN at meeting was J. B. Huffman, right, being congratulated by R. L. Hiller, National Membership Chairman, and President R. H. Bescher. Hiller, on behalf of American Cyanamid Co., presented Huffman with set of dishes.

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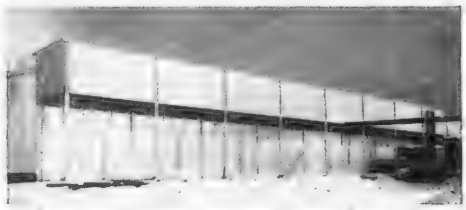

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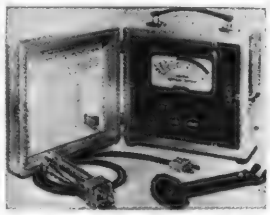

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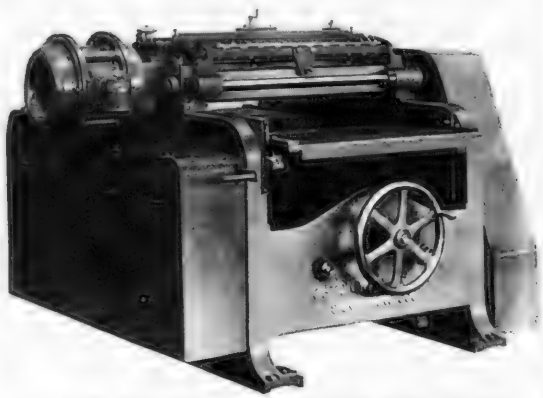

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Challenging Possibilities of Forestry and Forest Products Research[1]

REUBEN B. ROBERTSON, SR.

President and Chairman of the Board, Champion Paper & Fibre Co., Canton, N. C.

WHILE NO EXPERT IN FORESTRY, I have been exposed to its practices for half a century and have acquired enthusiastic convictions to which I give continued support.

When I came to North Carolina in 1906, there were only a handful of trained foresters in the country. Prominent among them were Gifford Pinchot and Dr. Carl Schenck, both of whom took a special interest in western Carolina. The white pine plantations on the Biltmore Estate, with their proved annual production of more than two cords per acre per year, constitute a lasting monument to the efforts of these pioneers.

In those days a demand for forest research would have been a futile gesture. As the years have passed, however, we have witnessed a steady growth in the philosophy of forest thrift and a steady decline in the forces of waste and destruction. We now *mine* fewer forest lands and *farm* more of them.

The company with which I am associated has, for many years, been research-minded, focusing attention on the chemistry and physics of papermaking. We point with pride to a number of firsts that have been accomplished by the joint efforts of Champion research and operating teams. Our mill at Canton was the first large pulp mill in the South, as well as the first to utilize both alkaline and acid processes for the pulping of hardwoods and softwoods. It was the first to develop a double use for chestnut—the preliminary extraction of tanning material and a cheap source of wood for soda pulp. It was first to purify and market turpentine and the tall-oil by-product of the digestion of resinous wood. Such instances as these have convinced us that research is worthwhile.

Someone has outlined the specifications of a research worker in these terms: "He must have the simplicity to wonder, the ability to question, the power to generalize, and the capacity to apply." These are fine characteristics, but not always easy to find in one individual. In gathering talent for research, often we must acquire the various required skills through a number of individuals rather than by looking for a single person of such unusual attainments.

In our objectives we must distinguish between the practical and the visionary. As one distinguished research engineer has said, "Let your dreams roam the skies, but engineer them back to earth."

Forest research is going on in two distinct fields. Methods of harvesting forest crops are receiving intensified attention in the search for lower costs and more complete utilization of forest products. This is an age of mechanization, and increased mechanization possibly to the extent of automation to a limited degree is to be expected. For best results, however, we cannot ignore the relationship between the character of the forest and the method of harvesting. Selective cutting presents obstacles to complete mechanization far greater than when clear cutting of planted forests is feasible. Studies on better coordination of timber growing and harvesting have inviting possibilities.

Forest products are bulky in proportion to value and transportation costs are of vital importance when we approach the problem of profitable utilization. The advent of state-wide systems of highways has revolutionized the transportation of forest products. The bulldozer has permitted the extension, at low cost, of temporary logging roads into the heart of the timbered areas so that trucks can be loaded practically at the point where the tree is felled.

In the mills we see more complete utilization through removal of bark before the log is sawed, permitting the sale of slabs and edgings for fiber-making purposes. Both sawdust and shavings are steadily being used more extensively for fiber or chemical content value, but we have by no means reached the end point in this area.

Fascinating Future

Economic pressures are stimulating interest in the utilization of all wood by-products and extractives. Our chemists freely admit that there are vast areas in the chemistry of lignin and of cellulose that remain unexplored. In this field no one can yet foretell what the future has in store, but it is sure to be fascinating.

Chestnut wood in the Appalachians, prior to the coming of the blight, furnished a fine example of a profitable double-use of timber. Chestnut extract sold to the tanner lessened by a substantial amount the cost of wood to the pulp manufacturer. There are other potential double-use woods such as button wood, snake wood, and mangrove which warrant investigation, even though they may not offer as attractive possibilities as chestnut did.

At present, Appalachian hardwoods, especially of the so-called weed tree variety, are in abundant supply, while pine stumpage carries a premium. We need more knowledge and better techniques for converting hardwood or hardwood-pine lands into the more profitable stands where pine predominates.

The field of forest genetics and the possibility of developing hybrids of more desirable characteristics is receiving more and more attention and, better still, is being supported by contributions from private and public sources of substantial size. It is generally understood that studies in forest genetics require not months—not years—but decades, before reliable results can be obtained. Such studies must extend beyond the span of life of the individual. It is necessary, therefore, to resort to corporate or institutional support to obtain the vital continuity of effort. The flash of genius no doubt accounts for many inventions but slogging, patient, persistent, and continuous scientific effort will account for most of our real progress and this kind of research takes time.

In this field, I believe that we are "at the opening verse of the opening page of the first chapter of endless possibilities." I envy you, who are giving thought to research, on the challenging possibilities that lay before you.

[1] Summary of address at FPRS Official Luncheon, June 5, 1956, during Tenth National Meeting in Asheville, N. C.

The Author: R. B. Robertson received A. B. from Yale University, attended Law School of U. of Cincinnati and was admitted to bar in 1903. He joined Champion as general manager in 1912, has served as vice-president, executive vice-president, and president. A pioneer in development of voluntary forest conservation programs, he has received numerous citations for his business and civic activities.

LEO A. ISAAC, research forester for U. S. Forest Service and world's leading authority on Douglas fir silviculture. The information developed through his 30 years of research at Pacific Northwest Forest and Range Experiment station has been reported in more than 50 publications and now serves as a basic guide for the management of Douglas fir.

scientists of the forest help grow more wood for tomorrow...

Forestry research has resulted in growing assurance that tree farms can always produce wood for use in lumber, paper, rayon, chemicals, and about 4,000 other products.

To supply America's increasing demand for wood, the nation's forestlands must be kept productive by growing timber in repeated crops. Toward this end, forest scientists in industry and government are working together to acquire a more accurate knowledge of tree life through research. Typical of the men in this field is Leo A. Isaac, research forester and world-recognized authority on Douglas fir. His studies in seed distribution, natural reforestation and harvesting methods have helped establish basic forest management practices used in the Douglas fir region.

Today, forestry research programs are concerned with improving both the quality and quantity of future timber crops. The effect of seed selection, forest soil, pruning and thinning upon tree growth is under concentrated study. As a result of these experiments, America's 8,500 private owners of industrial tree farms will be able to grow *more* wood per acre for the forest products of tomorrow.

Weyerhaeuser Timber Company maintains a large forestry research staff to develop methods used in managing its forestlands as tree farms. *For free literature on tree farming, write us at Box A, Tacoma, Washington.*

Weyerhaeuser Timber Company

FPRS Forest Products Journal

Vol. VI, No. 10
October, 1956

The First Ten Years of FPRS Progress[1]

FRANK J. ROVSEK

Executive Secretary, Forest Products Research Society, Madison, Wis.

Compiled from various correspondence, reminiscences, and Society records, this is a brief history of the formation, purposes, and growth of the Forest Products Research Society from its origin to the present day. To FPRS' more recent members, it will serve to round out their understanding and appreciation of the work to which they are contributing. To our original members, it is a tribute to their patient and faithful support through this past decade.

THE NEED FOR A SOCIETY to serve as a clearing house of forest products research and development was recognized by enlightened industry leaders for many years prior to World War II. True, there were a number of technical societies that served individual segments of the industry, such as forestry, pulp and paper, but no one group was devoted to the broad concept of forest products, including lumber, allied products, millwork, construction, furniture, and the vast range of secondary manufactured products.

Impetus of Wartime Research

World War II, with its emphasis on full mobilization of both manpower and resources, provided the impetus for the eventual formation of the Forest Products Research Society. It brought together, for the common effort, the skills of the logger and lumberman, the furniture manufacturer, the plywood producer, and pulp, paper and other industries. It focussed effort on cooperative research, much of which was channeled through the U. S. Forest Products Laboratory in Madison, Wisconsin, the world's largest organization devoted to fundamental forest products research.

Working together, government, education, and industry wood technologists and scientists made unprecedented progress in providing our industries and armed services with the "know-how" to produce and use better wood products. An example of such progress is best illustrated by recalling that through the efforts of forest products research, principles of package design were so advanced that by the end of the war our merchant marine was able to carry the previously normal cargo of five ships in just four — a clear saving of 20 per cent of our merchant fleet.

It was only natural, then, that at the close of war these same men who had worked so closely together as a team for the war effort should foresee even greater results through cooperative effort in peacetime. The need for interchange of information and the promotion of more efficient utilization does not stop with the end of hostilities; it becomes even more vital in the rehabilitation period that follows. These men recognized the need for maintaining lines of communication open between industry, government, and education, and conceived an organization that would fulfill that need.

A second and perhaps equally important factor in the development of the Society was economic. Within the span of a few years, our forest resources took on new meaning in the overall economy. It was recognized that new industrial, population, and standard of living goals for the future would require ever-increasing amounts of wood. The tree came to be looked upon as a valuable commodity, to be sustained on a perpetual-yield basis, much as farm crops, and to be utilized in fuller measure than ever before.

Movements that Preceded FPRS

The actual formation of the Forest Products Research Society was preceded by two separate but parallel movements. The first occurred on the west coast in November 1945, when Art Mottet, Research Engineer, Long-Bell Lumber Company, with the help of Al Herman, Director of Research for the Western Pine Association, gathered a group of interested persons at a meeting in Seattle. There they organized the Associated Forest Products Technologists, the forerunner of the Forest Products Research Society.

Also, on July 20, 1945, at Detroit, Michigan, a meeting was held of the Forest Products Research Committee of the Michigan Planning Commission. It was moved that the Chairman, Dr. Grover C. Dillman, President of the Michigan College of Mining and Technology, contact the U. S. Forest Products Laboratory to suggest a nation-wide meeting of representatives of states interested in forest products research and to effect a plan for ex-

[1] The author wishes to express his appreciation to the persons who have contributed their thoughts and experience to this article. They include: the FPRS editorial staff, Edward H. Roche, Ruth G. Napp, and George H. Schmidt; the U. S. Forest Products Laboratory for its accurate records of the 1946 conference; and the past presidents of the Society who have taken time to review and comment on various parts of the article.

1947 Executive Board: Carl Rishell, Jim Hamilton, Bror Grondal, George Garratt, President Fred Gottschalk, Bill Baker, Bob Cockrell, Ed Locke, Jac Tigelaar. Not present: Ken Chesley.

1948 Executive Board: Hamilton, Chesley, Bob Pauley, Cockrell, Charles Van Hagan, President Garratt, Gottschalk, Locke, Tigelaar, Charles Van Epps. Not present: Rishell.

1949 Executive Board: (Standing) Chesley, Lester Carr, Pauley, Ralph Bescher; (seated) Carter, Hamilton, Garratt, Van Hagan. Not present: President Locke, Rishell, Van Epps.

change of information among such states. George M. Hunt, Director of the U. S. Forest Products Laboratory, replied that they were agreeable to such a conference and expressed the belief that it could be productive of much good.

This action culminated, March 18–20, 1946, in a "Conference on State and Federal Forest Products Research Programs" at Madison, Wisconsin, attended by 88 representatives from states, universities, and the U. S. Forest Service.

Early in the conference Mr. Hunt emphasized the need for interchange of research information, noting that "duplication or repetition of the work of other investigators is often a waste of time that should be put to better use." He added, "No group can build a fence around its research activities and require that all others keep out of that area. On the other hand, no research worker should duplicate or repeat the work or research program of another unless he has a good reason to do so."

Also raised, as one of the conference's major decisions, was the question of "the establishment, if the consensus wishes it, of a more or less permanent system or organization to facilitate the exchange of information between individuals and organizations of the several states and the Forest Products Laboratory."

Opening the second evening of the conference, Mr. Hunt called on Bror L. Grondal, chairman of the preconference committee which was formed to discuss and make preliminary plans for a society, to outline his proposal. Professor Grondal discussed the aims of such a society. He said, "There is great lack of interchange of ideas among the men engaged in this work, and they lack close contacts with one another." He drew attention to the Associated Forest Products Technologists in the Pacific Northwest and said there was enthusiasm for the formation of similar societies in the South, Southeast, and Northeast. "However, local organizations while they fill the bill to a degree, cannot function as effectively as a national organization would." He then proceeded to read from a proposed constitution for a forest products research society, the result of correspondence and personal meetings between members of the preconference committee.

It is both of historical interest and a sign of great vision that the original purposes and objectives as read at this meeting have continued, almost word for word, to guide the destiny of our Society to this day. They were briefly: "1, to facilitate interchange of information; 2, to abstract results of research; 3, to publish and distribute information; 4, to encourage cooperation among individuals and organizations; 5, to promote standard test methods; and 6, to sponsor meetings." The proposed constitution also defined three types of membership as: voting, associate, and supporting.

Industry Participation Invited: Grondal continued, "We consider it unwise to propose immediate adoption. Until the men in industrial research have been brought in with us and have something to say about it, final action should be deferred. This committee does, however, want to lay this proposal before you: that this group tonight endorse formation of this type of society and that this or another committee meet with industrial groups to draw up plans for such a society."

Some of the comments that followed the proposal are worth noting:

R. A. Cockrell, California: Such a society can abstract results of research. Many of us are not familiar with progress of other research agencies.

F. H. Kaufert, Minnesota: I want to say that I endorse the principle and think it will be a useful thing.

O. H. Schrader, Jr., Washington: I would like to point out that AFPT in the northwest is not patterned after other professional societies. We bridge all the groups.

N. Gilbert, Tennessee: I don't believe the society should be restricted to persons in research but include people interested in utilization.

S. T. Dana, Michigan: I like the plan to bring industry into the picture early. As to scope of membership, its primary purpose would be to improve utilization of forest products and research is only a part of the picture. A society not strictly professional but broader in scope would be more useful in the long run. It should admit to membership persons interested in the application of research.

H. L. Shirley, New York: I feel there will ultimately be as many technical men engaged in forest products research as in forestry. Many will be trained in forestry schools but others will get their training as engineers, chemists, and in other fields. If that group could be welded together, such a society is very much in order.

L. J. Markwardt, Wisconsin: We have quite a number of professional societies. These function in specific fields, organized along vertical lines. There is a need for societies organized along horizontal lines, that cut across the fields of the professional societies. This society needs similarly to be organized horizontally, with membership open both to those in different professions interested in forest products and to those who have a technical interest in this field. It would thus cover the whole area that can't be covered by the professional societies.

At the conclusion of the discussion, Dean S. T. Dana moved: "that the preconference committee be requested to continue to act and include in its membership men from industry, with a view to working out the general plans for an organization." The motion was seconded and carried. On further question by G. M. Hunt, it was moved and seconded that this conference instruct the committee to proceed with the formation of the new society.

FPRS Founded, January 19[illegible]

Between March 1946 and January 1947, the organization committee was enlarged to include representatives from industry and on January [illegible]14 members met to formally establish the

1950 Executive Board: Van Epps, Hertzler, Chesley, Rovsek, President Hamilton, Locke, Pauley, Carter, Christian. Not present: Bescher, Carr.

1951 Executive Board: Hertzler, Pauley, Hamilton, President Carter, Bill Wilkins, Fred Armbruster, Bescher, Chesley, Carr, Christian.

society, collect dues, elect officers, and select the name, Forest Products Research Society.

Those present were: William J. Baker, U. S. Forest Products Laboratory, (deceased); Kenneth G. Chesley, Director of Research, Crossett Lumber Co.; Harold S. Crosby, Forest Products Engineer, Northern Hemlock and Hardwood Association; George A. Garratt, Dean, Yale University School of Forestry; Fred W. Gottschalk, Technical Director, American Lumber & Treating Co. (now President, Mackintosh and Truman, Inc.); Bror L. Grondal, Professor of Forestry, University of Washington; James F. Hamilton, Technical Service Director, Perkins Glue Co. (now Field Technologist, Michigan College of Mining and Technology); R. N. Hammond, Weyerhaeuser Timber Co. (now Consultant, Seattle, Wash.); Charles B. Hemming, Chief Chemist, U. S. Plywood Corp.; George M. Hunt, Director, U. S. Forest Products Laboratory (now Special Adviser and Consultant to the Philippine government in the establishment of the Forest Products Laboratory, College Laguna, Philippines); Gordon O. Marckworth, Dean, University of Washington College of Forestry; L. J. Markwardt, Assistant Director, U. S. Forest Products Laboratory, W. H. Swanson, Director of Manufacturing, Kimberly–Clark Corp.; and Jac H. Tigelaar, Director of Research, Haskelite Manufacturing Corp.

Of this original group whose foresight brought into being the Forest Products Research Society and which, ten years later, numbers 3,200 strong in the U. S., Canada, and 39 other countries, Grondal later says of Hunt's contribution, "If anyone deserves credit for organizing the Society, it is George Hunt. He got behind the idea and really pushed it."

Objectives Unchanged through Years

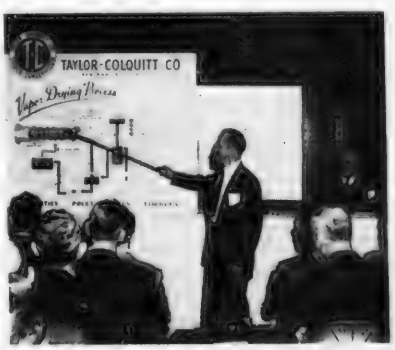
The founders of FPRS intended it to be a *broad organization* "open to all persons interested in research, development, production or utilization of forest products." They decided that the organization should be composed not only of highly trained and specialized scientists in the industry, but that all phases of the industry be brought together, from the mill worker to the top executive. Only in this way would it be possible to bring about interchange of ideas at all levels. The founders also expressed a need for the Society to cut across fields served by existing professional societies, but that it should in no way supplant their services.

The objectives and purposes of FPRS were stated clearly as including: the publication of information, conducting section and national meetings, encouraging close cooperation between all segments of industry, education and government laboratories, encouraging high standards of test methods and procedures, and digesting reports and other publications of interest to the industry.

On August 8, 1947, the Society became legally existant through incorporation as a non-profit organization in the State of Illinois.

How FPRS Serves Members and Industry

The Society was founded on the principle of ever-increasing service to its membership, and to carry out this objective its work is divided into five principal operations: the executive board which establishes national policies, the local sections which serve the needs of a specific geographic area, national meetings which provide for contact between all members and officers, the standing committees and divisions which originate meeting and publishing information, and publications which disseminate information to the membership and the world at large.



Technical sessions at First National Meeting in Chicago set pattern for years to follow. Speaking is author Monie Hudson.

Executive Board

A cardinal requirement of a strong organization is a nucleus of strong leadership. FPRS has been fortunate to have had from its very beginning well-balanced, competent, and enthusiastic Executive Boards representing the interests of government, industry, and education. They have worked within the framework of the organization to establish, define, and coordinate the many functions of the Society and to see that it properly serves its members.

The Society has also had the good fortune to have the financial assistance of its Company Supporting Members, who have grown from 17 in 1947 to over 100 today. These organizations have contributed substantial dues, which have proved invaluable in the strengthening of the Society's services. Still other companies, and in many cases the same supporting organizations, have also generously underwritten the travel and participation expenses of both national and section officers.

The first executive board meeting was held in 1947. Fred W. Gottschalk was elected president; George A. Garratt, vice-president; and William J. Baker, secretary-treasurer. Bror L. Grondal, who served as organizational chairman and as chairman of this board meeting, was elected to serve in the office of past-president, inasmuch as there was no actual past president. Six geographic regions were established with representatives elected for staggered terms. The first regional board members were Kenneth G. Chesley, Robert A. Cockrell, James F. Hamilton, Edward G. Locke, Carl A. Rishell, and Jac H. Tigelaar.

Fred Gottschalk was succeeded by George Garratt as president in 1948. The other men who subsequently have served in this capacity are: Edward G. Locke, Chief, Division of Wood Chemistry, U. S. Forest Products Lab.; James F. Hamilton, Field Technologist, Michigan College of Mining & Technology; Roy M. Carter, Professor of Wood Technology, North Carolina

1952 Executive Board: (Standing) Carter, Christian, Ray Shreck, Wilkins, J. A. Hall, Armbruster; (seated) Pauley, President Chesley, Carr. Not present: E. E. Dargan.

1953 Executive Board: (Standing) Wilkins, Scotty Harrar, Hall, Armbruster, W. Jeter Eason, Shreck, Rovsek; (seated) Christian, Carr, President Pauley, Chesley.

State College; Kenneth G. Chesley, Director of Research, The Crossett Company; Robert D. Pauley, Manager, Special Products Division, Weyerhaeuser Timber Co.; Lester J. Carr, General Manager, L. J. Carr & Co.; Moss B. Christian, Director of Research, Chicago Mill and Lumber Co.; and current president, Ralph H. Bescher, Assistant to Vice-President and General Manager, Koppers Co.

The basic structure of the Executive Board has remained the same since the time the board was established, although the office of first vice-president has been changed to president-elect, with the man holding this position succeeding automatically to the presidency. The board is comprised of 11 members: president, president-elect, vice-president, past-president, six regional representatives, and the executive secretary who is appointed annually. It meets two times a year, once during the national meeting and again in the fall.

Secretaries Who Have Served: During the early, growing stage of the Society, the Executive Board was faced with numerous problems in developing a permanent staff. William Baker, the first secretary-treasurer, who served without compensation, resigned from the U. S. Forest Products Laboratory in October, 1947, to return to the staff of the Oregon Forest Products Laboratory. Baker was succeeded on a part-time basis by T. R. C. Wilson, retired U. S. Forest Products Laboratory timber mechanics chief and consultant.

Working closely with all of the secretaries who have served has been Marie T. Roberts, until 1950 assistant secretary. Subsequently she returned to her permanent assignment of Secretary to the Director, U. S. Forest Products Laboratory.

The membership and work load of the National Office grew so rapidly that the Executive Board decided to engage the services of a full-time secretary-treasurer, and in 1949 Charles E. Van Hagan, former member of the U. S. Forest Products Laboratory Information and Education staff, was appointed the first full-time secretary-treasurer.

Under VanHagan the Society continued to gain membership and among other accomplishments held its first successful combined National Meeting and Industry Show. The number of new sections increased also, and the forerunner of present FPRS publications, the FPRS monthly Newsletter, was developed, appearing in WOOD magazine. Two years later VanHagan resigned to return to government service. George M. Hunt served as interim secretary until on June 25, 1950, Frank J. Rovsek, formerly with the Advertising and Public Relations Department of Allis–Chalmers Manufacturing Company, Milwaukee, was appointed executive secretary, a post he still holds.

Notable Board Actions: Through the years the board has enacted many beneficial measures for its members and the industry. For example, during its first year the board approved acceptance of overseas members and in 1948 had members in 17 countries outside of the U. S. and Canada. The following spring it established a student membership grade at $3 per annum. About this time it also approved plans for cooperating with Vance Publishing Company, Chicago, in administering the "Wood Award" to outstanding students in undergraduate and graduate curricula, a program which has continued to the present and is now known as the "Wood and Wood Products Award" after the magazine of the same name.

Emphasizing the international scope and responsibilities of FPRS, the board named George A. Garratt to represent the Society at the United Nations Scientific Conference at Lake Success, N. Y. in 1949. In December of that year, the first FPRS employment committee was formed.

After successfully guiding the Society through its early years, the board noted in 1950 that the Society's growth was such that its constitution and by-laws no longer covered the diversified activities of the organization and its members. The board decided to revise these documents for the approval of the members. The following year Kenneth Chesley was named chairman of a committee to revise these documents and at the same time clarify the Society's section boundaries. The new constitution was ratified by the membership at large in 1951.

At the outbreak of the Korean hostilities the Executive Board, noting that the Society came into being as an outgrowth of the war effort in World War II, promptly offered the services of FPRS to the government. A wire to this effect was sent to President Truman and a reply was received, noting that the offer had been referred to Stuart Symington, Chairman of the National Securities Resources Board. The reply commended the Society for its patriotic spirit.

In 1953 the board faced the problem of industry shows held in conjunction with national meetings. Although three such shows had been sponsored by FPRS, the board felt that at this early stage of growth and with the limited executive office staff, the Society should not continue the financial undertaking of large industry shows. It did not, however, exclude the sponsoring of subsequent table-top type exhibits.

Plans for Permanent National Office: As the Society continued to grow, the board recognized the need for a permanent office to house the Society. The first step toward eventual permanent quarters was made in May 1954 through the purchase of a lot on North Walnut Street, Madison, in the proximity of the Forest Products Laboratory. W. J. Eason, Vice-President of Nickey Brothers, Inc., Memphis, member of the Executive Board, and architect, offered to design the proposed FPRS national office building. In the fall of 1955, an Executive Office Building Fund Raising Committee was appointed with Ralph H. Bescher as chairman to study the ques-

1954 Executive Board: (Standing) John Ritchie, Eason, Frank Parrish, Hall, Harrar; (seated) Pauley, Bescher, President Carr, Christian. Not present: Shreck.

1956 Executive Board: (Standing) Dick Warner, Bill Irwin, Ritchie, Charlie Lockard, Bob Hiller; (seated) Ray Berry, Frank Kaufert, President Bescher, Christian. Not present: Eason.

tion of raising adequate funds for financing the new building. This chairmanship is currently held by Raymond Berry, Scott Lumber Co., Burney, California.

National Meetings

One of the objectives of FPRS is "sponsoring meetings for the presentation and discussion of reports, investigations, and experiences of its members and others, and the interchange of ideas." One of the principal of these is the National Meeting held each year.

National meetings have been held in each region of the country, East, Midwest, South, and Pacific Northwest. Highlighting these meetings are the technical sessions, at which are presented papers covering the newest and latest developments in wood technology and related fields. These meetings are open to all and questions and discussion of the papers are encouraged. Field trips are usually arranged to nearby plants and social events of interest to men and women are also planned. Occasionally table-top type exhibits to provide an added service to suppliers are held in conjunction with the meetings.

The first annual meeting was held in October 1947 at the Furniture Mart in Chicago. The first "Wood Award" was presented at the second annual meeting in May, 1948, also held at the Furniture Mart in Chicago. Nicholas V. Poletika of Yale University, now Director of Research at Timber Engineering Co., was the first recipient of the award for his paper, "A New Method for Studying the Elastic Behavior of Wood."

Seventy-six companies exhibited at the first industry show to be held in conjunction with FPRS at the third annual meeting held at Grand Rapids, Mich., in May, 1949.

Moving from the Midwest for the first time, the fourth annual meeting was held at the Multnomah Hotel in Portland, Oregon, in June 1950. An industry show was held in conjunction with the meeting at the Portland Armory.

Historic Convention Hall in Philadelphia was the site of the fifth annual meeting, May, 1951. More than 80 firms exhibited at the industry show, which was attended by an estimated 2000 persons.

Milwaukee was the scene of the sixth annual meeting held in June 1952, which also included a special trip to the U. S. Forest Products Laboratory and the FPRS executive office in Madison.

Dixie played host to the seventh annual meeting at Memphis in June 1953. Representative Harris Ellsworth of Oregon addressed the official FPRS luncheon.

The nation's "furniture capital", Grand Rapids, Michigan, once again occupied the attention of the entire wood industry during the eighth annual meeting in 1954. The meeting attracted a record attendance of 863 persons to its technical sessions, with over 5000 persons attending the separately conducted Woodworkers Industry Show. J. P. Weyerhaeuser, Jr., President of the Weyerhaeuser Timber Co., discussed the now-famed Stanford Research Institute study projecting the nation's forest products needs to 1975.

The Pacific Northwest was the scene of the ninth national meeting held in June 1955 at Seattle, Wash. Author and philosopher Stewart Holbrook signalled the requiem of the old-time lumber baron and hailed the progressive trends in forest products management.

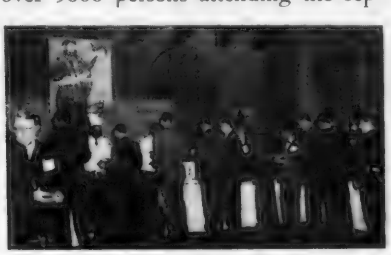
FPRS members and guests returned to the Southland for the tenth annual meeting at Asheville, N. C. in June 1956. Official registration was 808 with more than 1,000 persons viewing the wood industry table-top exhibits in the Civic Auditorium.

Reuben B. Robertson, Sr., President of the Champion Paper and Fibre Co., cited new trends in the industry as he addressed the official FPRS luncheon. Dr. Thomas R. Truax, retiring Chief of the Division of Timber Processing, U. S. Forest Products Laboratory, received a special citation for his "years of service and leadership in research".

FPRS' 13 Sections

Although the founders envisioned a national organization that would cut across all the existing fields within the

Secretary Tom Wilson records official minutes at Second National Meeting, Chicago, 1948.



FPRS members were guests of suppliers at first annual Paul Bunyan Hour, Furniture Mart, Chicago, in 1948.

Nicholas V. Poletika, now Director of Research, Timber Engineering Co., received first Wood Award from Dick Art, editor, at 1948 meeting.

forest products industries, they also recognized the similarity of interests within geographic areas, such as lumbering in the Northwest, furniture manufacturing in the Great Lakes, pulp and paper manufacturing in the South, and millwork and marketing in the Midwest. With this in mind the Executive Board in 1947 provided the machinery for the establishment of local sections. The Society membership expanded far beyond the early expectations of the charter members, and to date 13 sections have been established in the U. S. and Canada.

Rarely photographed George Hunt, center, registers at 1949 National Meeting. At right is Marie Roberts, U. S. F. P. L., who later served as FPRS assistant secretary.

First wood industry machinery and suppliers' show under auspices of FPRS was in Grand Rapids, 1949.

Second annual Executive Board-Section Officers Advisory Committee meeting, Portland, 1950.

Group of Carolinas members and ladies enjoy FPRS banquet, Philadelphia, 1951. Foreground, Mrs. Sig Johnson.

The first section was the Pacific Northwest, where already existed the enthusiastic Associated Forest Products Technologists. Two of the key figures in that organization, Bror Grondal and Edward Locke, felt that AFPT could best serve its aims by affiliating with FPRS as a section. In May, 1947, the 125 members of AFPT attending their third annual meeting voted to join FPRS as a body. Richard Hammond was elected the first chairman with Clarence D. Stone as first secretary-treasurer.

The sections were not intended to be mere arbitrary geographic divisions of Society members, but were established for the purpose of holding one or more meetings each year to present papers and discuss problems of current mutual interest within their respective areas.

The Society's first section meeting was held by the Pacific Northwest Section on February 17, 1948, in Seattle, Wash. Ten days later the Northeast Section held its organization meeting in New York City, concurrently with the organizational meeting of the Midwest Section in Chicago. On February 29, FPRS members in Florida met to establish a section in that area and in March 1948, it became known as the Florida-Georgia-Alabama Section. The Northern California Section followed in September 1948.

Following in rapid succession, FPRS members in the Atlantic coastal states met to organize the Virginia-Carolinas Section, which later changed its name to Carolinas-Chesapeake. The seventh section came into existence in January 1949, when the Inland Empire received approval from the executive board.

The Deep South Section (now Mid-South) was formed in June 1949, while at the same time members in Michigan, Minnesota, and Northern Wisconsin met to plan sections. The Michigan group held its first meeting in November 1949. Two years later the section expanded to include FPRS members in the northern portions of Ohio and Indiana and the name was changed to the Great Lakes Section.

Fourteen charter members in the Los Angeles area received authorization to form a section, the Southern California, which was formally organized in October 1950. The name later was changed to Pacific Southwest.

Members in the Paul Bunyan country formed the 11th FPRS chapter in November 1951 as the Upper Mississippi Valley Section.

Seven months later the number of sections became an even dozen with members in the southern Ohio, Indiana, and Kentucky area forming the Ohio Valley Section.

Although Canadian members were affiliated with the Society as a section in the early years, and subsequently with sections bordering their provinces, members in the eastern and maritime provinces decided to again form their own section, the first outside the U. S., in May 1952. In July 1952 at Toronto steps were taken by the Canadian Institute of Forest Products to join FPRS as a body, and the CIFP was officially incorporated into FPRS as the Eastern Canadian Section at Montreal in March 1953, forming the 13th FPRS section.

Committees and Divisions

With due respect for the importance of the executive board and section leaders, who determine and administer policies of the Society, it is the committees that accomplish the production. Working at the national level, planning national meetings, governing finances, raising funds and membership—and most important of all, planning and locating papers for technical programs—are some 20 committees, of which 14 cover technical divisions.

The divisions comprise: glues, wood preservation, marketing, packaging, veneer and plywood, machining, seasoning, finishing, lumber, logging, wood composition board, quality control, chemical utilization, and industry-education. Their principal purpose is to develop the technical programs for the national meetings, and to prepare year-end reports of progress in their fields. In addition, they are a medium for the interchange of technical information between experts and members in the field. Space does not permit listing the chairmen or committees heading these divisions; however, they will be found elsewhere in this issue.

Growth of FPRS Publications

Just as an army must maintain a smooth flow of communication through its chain of command to coordinate its operations, so too must any civilian organization with far-flung operations develop efficient means of communication.

The Society, through the years, has developed three principal publications: its ANNUAL PROCEEDINGS, the FOREST PRODUCTS JOURNAL, and its NEWSLETTER. The first of these was the NEWSLETTER which, as mentioned before, in the early years was incorporated in WOOD Magazine. Its purpose was to pass along news and views of special interest to the members pertaining to forthcoming meetings, new

publications, and so forth. Later, it became known as the NEWS–DIGEST and was mailed direct to the membership. Today, it is incorporated as a section of the JOURNAL.

Annual Proceedings and Journal: The second, and certainly greater publication, was the ANNUAL PROCEEDINGS, first volume of which came out in 1947. Covering the first national meeting, it contained 353 pages of articles and allied information. The Proceedings was published annually through 1952, when it was integrated with the JOURNAL OF FPRS.

A growing awareness through the years by the Publications Committee and the Executive Board, and increasing requests by the sections to provide a medium for the dissemination of section meeting papers, resulted in the introduction in September 1951 of the JOURNAL OF FPRS. The Journal started, naturally, as a quarterly, then increased in frequency successively to 5 times a year, then bi-monthly, and in 1956, monthly.

Editors Who Have Served: A great deal of credit for the early development, and editing, of the Proceedings and Journal is due two Forest Products Laboratory men who contributed part-time effort. They are Francis J. Champion, information specialist, and George M. Hunt, past-director. With the Journal's expansion grew the necessity for a full-time editor and in October 1952, Howard J. Rosenberry, formerly with WOOD AND WOOD PRODUCTS magazine, was appointed to that post.

In 1953, primarily for consolidation and postal economies, the Proceedings became an issue of the Journal. In 1955, through recommendation of the Publications Committee, use of the Proceedings as a sole repository for all national meeting papers was discontinued, and such papers were also distributed through other issues of the Journal. To fill certain functions of the Proceedings two new issues of the Journal were instituted, the February Annual Review number and the October Yearbook. Also, in 1955, the name of the Journal was abbreviated to read simply FOREST PRODUCTS JOURNAL. In February 1955, Edward H. Roche, formerly publications editor, New York State College of Forestry, was named editor, succeeding Howard Rosenberry. In 1956 with the introduction of the monthly Journal, Ruth Napp, University of Wisconsin journalism graduate, was named editorial assistant.

Some small idea of the growth of FPRS publications over the years is gained by a comparison between the 45 papers published in 1947 versus more than 180 papers expected to be published in 1956.

Highlight of 1952 National Meeting in Milwaukee was visit to U. S. Forest Products Lab, 80 miles west in Madison.

Milestones of FPRS Administration

No history of FPRS would be complete without some special mention of the contributions of the 10 presidents who have guided the Society to its present sound position. From a humble beginning of some 14 men in 1947, the Society has grown to become a respected authority in forest products research throughout the world. A great amount of this growth has come about through the untiring efforts of capable and dedicated men who have served as president.

During Fred Gottschalk's term, membership rose to a phenomenal 1200, far surpassing original expectations. The American Lumber and Treating Company enabled Gottschalk to devote full time to his duties as FPRS president and the early growth and expansion of the Society are a direct tribute to him and his company. He designed the first ANNUAL PROCEEDINGS and attracted a large amount of advertising support.

World Prestige: Dr. George A. Garratt, Dean of the School of Forestry, Yale University, succeeded Fred Gottschalk. Membership continued to climb, rising past the 2,000 mark, a 70 per cent increase in only 12 months. During his term, the Society sponsored the first successful woodworking machinery show.

Dr. Garratt held a world-wide reputation as a leading forestry educator and lent his international prestige to the establishment of FPRS as a global organization. In 1949 he represented FPRS at the United Nations Scientific Conference at Lake Success, N.Y., pointing up the world-wide significance of the Society.

FPRS was founded on the basis of service to the three sectors of forest products research efforts — industry, education, and government. Fred Gottschalk was industry's first representative George Garratt followed for education, and the cycle was completed in 1949 when Dr. Edward G. Locke of the U. S. Forest Service became president.

Section Expansion: While membership was rising steadily, President Locke saw that the Society must strengthen its local ties and build up and expand the sections. He travelled extensively throughout the country, giving counsel to established sections, assisting interested groups in establishing new sections, and encouraging members to other areas to lay the groundwork for forming sections. Through his efforts the Great Lakes, Carolinas–Chesapeake, Florida–Georgia–Alabama, and Mid-South sections came into being.

During the term of James F. Hamilton the Society began to reach a status of maturity with a strengthening of member services. A system for rebat-

View of portion of 341 persons who attended Official Luncheon at Memphis in 1953 to hear address by U. S. Rep. Harris Ellsworth, Oregon.

FPRS chiefs installed in Northwest Indian tribe at Paul Bunyan Potlatch, Seattle, 1955, were President Christian, Past Presidents Pauley and Carr. At right is Past President Roy Carter.

ing dues to individual sections to help underwrite costs of section activity was instituted. By mutual consent the monthly News Bulletin was discontinued in WOOD AND WOOD PRODUCTS magazine and an interim News-Digest was sent direct to each member. The FPRS long-range publications program was reviewed and steps were taken towards establishing a quarterly Journal in addition to the Proceedings.

Roy M. Carter succeeded to the presidency in 1951. Through his efforts a special Executive Board Committee on the development of subject matter committees was formed and subsequently instituted a program which today has grown to 14 separate divisions.

In 1952 the growth of the Society was such that a revised constitution and by-laws became necessary. It was only fitting that Kenneth G. Chesley, who had served as chairman of the constitution and by-laws committee since the Society was founded, should in his term implement the new constitution. His work has resulted in the democratic principles that now govern the Society and have brought about a marked growth in FPRS activities. More than 250 FPRS members hold some office on the national, regional, sectional, or committee level and many hundreds more actively participate through meetings — all in unison, all within the framework of our Constitution.

Robert D. Pauley became president in 1953 and recognized the need for planning FPRS facilities to meet the expectant future growth and needs of the Society. The program for a permanent FPRS office building was inaugurated, and arrangements made to purchase a site for the building. Also under President Pauley's direction the publications program continued to expand with all FPRS publications coordinated into an expanding Journal.

Lester J. Carr took office in 1954 and soon earned the title of "FPRS's Travelingest President", an honor he richly deserved for his efforts in behalf of the Society. Mr. Carr was constantly on the move, traveling more than 60,000 miles during his tenure and visiting every section serving as liaison between members and the national organization. He made the membership "public relations conscious" and through his writing strengthened the role of FPRS throughout the world.

Membership and Financial Strength: Moss B. Christian again emphasized membership growth as he took office in 1955 and the membership total soon shot past the 3,000 mark, reaching 3,200 as he completed his term. The publications program saw great improvement during this period with all FPRS publications coordinated into the now-monthly FOREST PRODUCTS JOURNAL. The Society attained its greatest financial stature at this time, with net worth after debts and obligations totaling $25,000.

Registration area at 1954 National Meeting in Grand Rapids, which set record of 863 attendance.

The reins were turned over to Ralph H. Bescher at the national meeting in June 1956 and he already has made great strides in carrying on the progress of previous administrations as well as surging forward towards the increased growth of all FPRS functions.

What Has FPRS Accomplished?

Even for those who have been intimately associated with the Society since its inception, it is difficult to look back and realize the strides which it has made in a decade. This progress can best be summed, again in the words of one of the 14 founders, George M. Hunt, who says, "Then we were nothing but an idea. Today we are a vigorous organization of over 3,200 members in 31 countries. We have 12 local sections in the United States and 1 in Canada. We started with $130; our budget last year was $80,000. Size of budget and number of members, however, do not necessarily indicate the value or usefulness of an organization. The usefulness of an organization is measured by what it accomplishes. The Forest Products Research Society, after ten years of activity, can confidently stand up to be measured by that yardstick."

"We have provided a means of publishing the thoughts and the findings of all who are concerned with forest products, whether the material to be published relates to chemistry, engineering, electronics, education, business management, or any other subject. The only requirements are that the material shall relate to some phase of the Society's field of interest, shall be well written, and shall be useful. We have already, through our publications, provided a storehouse of useful information that has reached the shelves of libraries throughout the world and is being studied and cited with increasing frequency.

"We have provided local sections so that members in different parts of the United States and Canada can get together at frequent intervals for discussion of problems of regional or local interest.

"We have aroused the interest of many companies and individuals and stimulated them to work more actively and aggressively for the advancement of our common interests. We have brought research and industry closer together in our field and this contact has given to each a greater respect and consideration for the other."

Wood Particle Board--A Giant in the Making

GERARD P. URLING

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Wood particle board production and utilization are discussed. Typical physical and mechanical properties based on tests of commercial particle boards are described. Diversity of products are foreseen as the future market of particle board.

Introduction

IN THE WOOD INDUSTRY, one of the major post-war developments has been wood particle board. While research and some pilot plant experiments were conducted prior to and during World War II, particle board did not appear on the market until about 1946. It is truly a contemporary material.

The growth of the wood particle board industry has been spectacular. In Western Germany, for example, the volume of board produced has increased from approximately 4½ million square feet in 1950 to 75 million square feet on a ¾-inch basis in 1955. There are now approximately 35 plants in Western Germany, three plants in England, and several in Switzerland.

Most research and development in the field was originally directed at utilization of woodworking residues but at least in Continental Europe the higher quality products rely on round wood from forest thinnings. In England, however, as in the United States, woodworking residues are the principal raw material.

There are approximately 46 wood particle board plants either producing or being built in the United States, and new plants are constantly being announced. During the past six months, these announcements have been running about one a month. The 1955 production in this country is variously estimated from 80 to 100 million square feet, on a ¾-inch basis. It seems clear that we are going to see a lot more particle board in the years to come.

Particle board should not be viewed as a substitute material but rather as a newly developed, engineered product having its own characteristics, advantages, and disadvantages just like any other product. As the name implies, wood particle board is essentially a product consisting of machined wood particles, such as splinters, flakes and shavings of a controlled moisture content and size, bonded together, using a synthetic resin adhesive, into panel form under pressure and heat.

Production of particle board at the present time is accomplished by two principal methods: the extrusion process and the multiplaten process. A third method, employing opposed and continuously moving belt-type platens, is also in commercial use; however, there are no such plants in this country. The extrusion and the moving platen methods are continuous processes characterized by the operation in which the board product emerges as a continuous panel, which is then cut to a specific length. The multiplaten process employs a multiple-opening hydraulic press in which a series of panels are formed in each operation. In the latter case, both the length and width dimensions of the panel are governed by the platen size.

The manufacture of wood particle board can be broken down into the following major phases:

1. **Reducing the raw material to particle form**—In the United States, the general practice is to reduce solid wood residue to splinter form by hammermills or hogs. The trend in Europe is toward the use of flakers, special machines which cut thin flakes.

2. **Drying the particles**—In operations using dry wood residues as a source for particles, this phase is omitted. Where green wood is used, drying of the machined particles to a uniform moisture content, usually 8 to 10 per cent, is necessary. As flakers, at present, are efficient only with green wood, driers are a requirement in many of the European processes. Drum, tunnel (belt), flash, and turbine driers are used for this purpose.

3. Screening the particles—Screening to obtain uniform particle size is an almost universal practice. Some rotating drum screens are used, but by far the most common type are vibrating pan screens.

4. **Proportioning and mixing the particles with the adhesive**—The simplest method of proportioning and mixing is the weighing of the wood particles and resin in batches and mixing them in a drum. In some such applications, the adhesive is added by a metered injection system eliminating the weighing of the resin. Because of the time involved in mixing individual batches, the trend is toward various methods which permit a continuous flow of particles and adhesives.

5. **Forming**—This is a very important phase as the uniformity of the final product is largely dependent upon an equal distribution of the adhesive-coated particles prior to pressing. Distribution of the mixture is usually accomplished by moving the chute through which the particles dropped, or moving the forming frame. Special devices have been developed to further aid in the equal spreading of the particles. In Europe, often a man is stationed at this point to assure uniform distribution because of the importance of this phase on the quality of the final product.

6. **Pressing**—Prior to the final pressing in most multiplaten processes, an unheated single-opening press or roll-type press is used to reduce the thickness of the mat. This pre-pressing facilitates handling but its chief purpose is to permit the use of shallow openings between the platens of the hot press. Other than the economics of press size and operation, the use of shallow openings has advantages because it prevents pre-curing of the adhesive while the press is closing. Faster-action presses, with greater openings, will accomplish the same results, and frequently are better for some operations than are the shallower presses.

Final shaping of the board and curing of the resin is accomplished in hot presses. Continuous processes may use oscillating ram or screw extrusion

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presses with fixed platens or belt-type moving platens operating like two opposed tractor treads. Multi-platen processes use multiple-opening hot presses.

The major impetus so far in establishing the wood particle board industry in this country and abroad has been from furniture producers. The board proper is being used to some extent for furniture elements but by far its most extensive use is for furniture core stock for both high-pressure laminates and hardwood veneers.

Particle board, because of its properties, probably is more suitable for furniture core stock than for any other readily available market. In the core stock field, the major competition is from edge-glued lumber cores.

In Germany, where particle board got its start, lumber was scarce due to wartime over-cutting and was high-priced. Even relatively crude particle board had a ready market. Had the particle board industry tried to push the board as a general construction material, there would have been severe competition with hardboard, brick, concrete, aluminum, steel, and other materials. It seems likely that, regardless of whether the specialization in core stock was intentional or just plain luck, the concentration on this single market was one of the most important factors in establishing the industry.

At present, approximately 60 per cent of all the core stock used in Germany is of particle board. It is predicted that for all practical purposes, the use of solid lumber for cores in Germany will disappear in another five years. The next few years will see an ever-increasing use of particle board by the furniture industry of this country. There are two basic reasons for this. The first one is the lower cost of particle board as compared to glued-up solid cores. Statements on the cost advantage differ, but no one disputes that there is a substantial differential. The second reason is that the forest product industries of the U.S. will be able to turn residues and low-grade lumber into high-quality products. With the ever increasing production of particle board in this country, knowledge of its properties becomes essential to producers and consumers.

Typical Properties

The various physical and mechanical properties of many of the commercially available wood particle boards have been determined in a comprehensive testing and evaluation program conducted at the research laboratory of Timber Engineering Company. As no standard procedures for testing wood particle board existed, most of the tests were conducted in accordance with the American Society for Testing Materials Standard D1037–52T, entitled "Evaluating the Properties of Fiber Building Boards".

Much valuable information and technical data were developed from this program.

The specific gravity of the various commercial boards tested ranged from 0.56 (35 pounds per cubic foot) to 0.72 (45 pounds per cubic foot) based on oven-dry weight and volume. The average specific gravity was 0.61 (38 pounds per cubic foot), which is comparable to average density oak or hard maple.

The bending strength or modulus of rupture for the various boards averaged 1828 pounds per square inch and ranged from 517 to 3,685 pounds per square inch, while the corresponding values for stiffness or modulus of elasticity averaged 299,200 pounds per square inch and ranged from 138,400 to 495,100 pounds per square inch. The bending specimens were cut both along the length of the boards and across their width. While most of the boards had similar strength in both directions, some boards, due to the forming process, had some particle alignment or planes of weakness which tended to make the board weaker in one direction. As particle board is usually veneered, panels having crossbands and face and back veneers, as is customary in regular furniture construction, were tested. This veneering approximately tripled the bending strength and doubled the stiffness.

In tests for dimensional stability, the wood particle boards having similar particle alignment in both directions exhibited similar dimensional changes, both along the length and across the width of the board. This, of course, differs from an edge-glued lumber core which expands and contracts, with moisture changes, more across than along the grain of the wood.

The particle boards of the homogenous type were, for the most part, more dimensionally stable than edge-glued poplar cores as measured across the grain of the wood. However, poplar cores, as measured along their grain, were more stable than particle board panels.

The particle boards showed less dimensional stability in thickness than they did in their other dimensions. This was due to springback, which results from the relief of the stressed condition of the compressed wood particles within the boards.

The hardness of the wood particle boards, as determined by the Janka ball test, generally exceeded that of yellow-poplar lumber. Values ranged from 515 to 1055 pounds, which is comparable to the hardness of red gum, at the lower limit, and cherry and walnut at the upper limit. The average hardness was 762 pounds.

The tensile strength perpendicular to the surface indicates the resistance offered to a force tending to tear apart the bonded particles along a plane parallel to the surfaces. This is, of course, a measure of the internal bond of the board material and is dependent upon such variables of production as resin content, wood particle shape and size, and pressure. Maximum tensile strength of the various commercial boards tested averaged 109 pounds per square inch and ranged from 18 to 261 pound per quare inch.

Screw-holding ability was determined in terms of resistance to direct withdrawal from both the face and the edge of the boards. To simulate the usual conditions where screws are turned into veneered panel backs, screw withdrawal from the faces was conducted on specimens having 1/20-inch yellow-poplar faces and crossbands. The edges of the specimens were not veneered. For both tests a 1–¼-inch No. 9 wood screw was imbedded to full thread depth in a ⅛-inch pilot hole.

The screw-retaining power of most of the specimens was significantly less from their edge than from their veneered face. The face-withdrawal resistance values averaged 340 pounds and ranged from 281 to 412 pounds, while the edge-withdrawal resistance values averaged 252 pounds and ranged from 148 to 310 pounds.

Some furniture manufacturers are using sheet metal self-tapping screws rather than the standard wood screw for fastening to particle board core stock. Teco's test results, however, have indicated little or no significant difference in the screw-retaining ability of wood particle boards receiving both types of screws.

Two factors, exclusive of those involved during the board-forming process, which improve wood particle board screw-holding ability, are a minimum pilot hole size and the addition of an adhesive to the pilot hole just prior to screw insertion. This is especially important when fastening to panel edges. Production-wise, the addition of glue may not be considered practical.

The wood particle boards exhibited excellent gluing qualities. These tests were conducted by gluing a piece of yellow-poplar lumber to the particle board and then testing the glue joint in shear. Failures occurred in the internal bond of the board material, thus indicating a glue joint stronger than the particle board itself.

The shape and size of the wood

particles generally determines the surface texture of the board. A slightly granular or coarse effect is present in boards composed of splinter-type particles. Some of the boards have a built-in smooth surface composed of wood particles in the form of flakes. This type of board may consist entirely of flakes or, as is often the case, may be of a three-layer sandwich construction having a coarser particle core between surface layers of flakes.

The particle boards tested were found to be readily machine-able. Sawing, planing, jointing, drilling, and routing operations may be adequately performed on wood particle boards with carbon steel tools. For continuous production machining, however, carbide cutting edges are recommended.

Due to the reconstituted nature of wood particle boards, there may be a tendency for fatigue or creep to occur in some boards when the material is subjected, for a long time, to heavy loads over a large unsupported space. An example of where this might occur would be a large table top with a heavy flower pot at its center. The table top might tend to have a permanent sag after some time; this would be due to creep occurring in the particle board, if adequate support was not provided. These characteristics should be considered in designing products in which particle boards are to be used.

Future Outlook

Certainly the future outlook for the particle board industry is bright. There is every reason to believe that the progress of the past ten years will continue. We have been talking mainly about particle board for furniture core material. As time goes on, we will see particle board being used in more and more applications.

At present, wood particle board is heralded as an answer to utilization of mill and plant residuals. Continued expansion of production facilities will necessitate a movement directly into the forest for material. Mobile chippers may be used for the harvesting of weed trees, culls, thinnings, and logging residues which are presently wasted.

With improvements in material processing and advancements in adhesives, boards with closely controlled properties will be possible. Various classes of boards will probably be available for the building trade. Boards will be developed for their thermal and acoustical insulation properties. New decorative effect will appear on the board face for display work and paneling, and more molding of items to shape can be expected.

At the Timber Engineering Company, we are confident of the continued growth of this industry. There is presently underway at this laboratory an over $200,000 expansion program, a large part of which will be devoted to a complete, conveyorized, production-type, wood particle board pilot plant of the multiplaten type, and additional testing facilities. The new pilot plant, expected to be in operation by early November, is being set up, not as a production plant, but to aid the wood industries in developing and improving this product, and establishing performance standards. It will simulate actual production, thus providing the next step beyond the laboratory or test-tube phase of development.

With the variety of types inherent in particle boards, and the increasing uses that will be developed, keen competition can be expected. Boards having performance claims backed by impartial, authoritative test data, logically will be given more consideration by prospective customers. With these authoritative test data, the particle board producer can assure his prospective customer of the product's quality and serviceability. Similarly, the customer can determine from the data whether the product complies with his particular requirements. Such mutual understanding and confidence between producer and consumer provide the elements most conducive to the industry's growth.

The particle board industry is moving so rapidly that, for the next five or six years, there will be continuous improvement in quality. By the end of that period there should be some leveling off but the producers of board probably will be making products that have slight resemblance to those of today. The firms that survive must meet this form of competition by modernizing their products as rapidly as is done by their competitors in the industry.

Wood particle board is the newest product of the forests and certainly appears to be a giant in the making.

Composition Board Has Found Its Place in the Furniture Industry[1]

ROLLIN H. YALE[2]

Wood Technologist, Poinsett Lumber and Manufacturing Co., Pickens, S. C.

Briefly traces development of composition board industry and points out that product's acceptance is based on its properties for specific uses. Twelve types of composition board were evaluated with respect to dimensional stability, hardness, and screw-holding power. Users of composition board can influence its development by specifying minimum standards for these properties.

A THORN IN THE SIDE of any organization is waste. For many years men in the lumber and woodworking industries have been vitally concerned with a suitable means of utilizing the tremendous volume of shavings, sawdust, small cuttings, and block waste which result from the manufacture of wood products.

The development of a wood particle type composition board originated more than 20 years ago in Europe, mainly through necessity because of diminishing forests. Swiss engineers deserve much of the credit for the early development of wood composition board. However, striving for a better product at a lower cost, particle boards have been further developed by allies to the woodworking industry as well as the woodworking industries themselves in all parts of the world.

At this inception, when composition board was tagged with the term "wood waste" board, it was looked upon by the consumer quite unfavor-

[1] Presented at Session XI, Composition Board, FPRS Eleventh National Meeting, June 4–7, 1956, Asheville, N. C.

[2] Mr. Yale was unable to attend the meeting and his paper was presented by Gilbert L. Kelly of the same firm

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ably. There was and still is a definite need for suitable terminology. Wood composition board should definitely not be considered as a substitute for wood but, as with all newly developed products in our industry, it is a by-product of wood and equally as effective as solid lumber for some uses.

There are definite disadvantages as well as advantages for a product of this type. However, as for the physical characteristics, it is entirely possible to produce a board which will meet the specifications needed for the particular application.

The ultimate use of the product is the determining factor in the type of board to be used. This should be kept in mind when making physical and mechanical evaluations.

Particle Board Uses

From an economical standpoint, wood composition board is one of the greatest developments made available to the woodworking industry. This material, which is made by coating wood particles with a resin adhesive and bonding under heat and pressure, forms a board that can be equal or superior to the raw material from which the chips came.

A wood aggregate board can be made exceedingly strong under the proper manufacturing conditions and compares favorably with solid lumber or a carefully balanced built-up core. It has already found a place in the furniture field as well as in the construction of houses. Dining room furniture, cedar chests, bedroom furniture, television cabinets, and sewing machine cabinets are some of the articles in which composition board has proved highly satisfactory. It is being used with equal success in desk tops in school rooms, counter tops in stores, truck and trailer bodies, or nearly any place that plywood can be used.

It is already being used in flush doors and wall panels, and with the incorporation of waterproof adhesives in its manufacture, we may find it can be used with equal success in etxerior construction.

Manufacturing Processes

Primarily there are three types of manufacturing processes for particle board in use today. The extruded process, in which the wood particles are forced, by means of a ram, between heated platens, is now in use in various parts of the United States and Canada. This process can be divided into two classifications: the horizontal process and the vertical process.

As the names imply, one operates on a horizontal plane and the other extrudes vertically. In the horizontal process there is somewhat of a tendency for the fine particles to settle to the bottom of the panel. This, in effect, results in an unbalanced construction which may cause warpage in the cured panel. There is also a definite orientation of the particles in this process. This has been corrected, however, in the vertical process. The extruded product also appears to have a definite grain direction. However, dependant upon the end use of the product, this might not prove undesirable for certain applications.

Fig. 1.—The composition board on the left was made by the multi-platen process whereas the board on the right was extruded. Both pieces were made by the same organization, and the ratio of chips to resin was the same.

Fig. 1 illustrates two sheets of wood particle board. Both were made by the same concern, with the same type of chips and equal resin additives. The one on the left was made by the multi-platen process while the one on the right is an extruded board. These panels were conditioned, upon receipt at our plant, at 6% E.M.C. and were photographed immediately after withdrawal from this condition. There appeared to be a settling of fines on the bottom of the extruded board, which accounts for the warping tendency.

The molded type particle board utilizes only very fine particles under considerably higher pressures with an increased amount of resin binder than is used in other processes. This results in a much higher density product than is desired for the normal furniture manufacturer. Some of the uses for this type of product are croquet balls, shoe heels, and toilet seats.

The multi-platen process of manufacturing composition board can be divided into many classifications. The type of products which can be made are varied. Although the initial cost is somewhat higher than the extruded equipment, the types of boards that can be produced will suit almost any need. In a multi-platen board, the particles are arranged parallel to the face of the board, giving no definite grain direction. Due to the manner in which the chips are dispersed onto the loading caul, there is very little chance of the extremely fine particles settling to the bottom of the mixture. This minimizes warpage possibilities in this type of board.

If the surface of the particle board is to be used in the finished product, a layer consisting of either shavings or fines can be used on the faces to give the desired smoothness. Both types are currently available on the market today and have proved highly satisfactory.

If the board is to be used as the core in a veneered construction, adequate smoothness can be obtained, after planing or sanding, from a sliver-type board. The size chips most widely used for this type of board are not less than 1/16 inch in thickness, and range upwards to 1-¼ inch in length. Work has been done on the West Coast in which larger pieces of veneer, as long as 3 or 4 inches, have successfully been made into a composition board.

What the User Requires

There are many factors which must be considered in determining "what makes a good composition board".

A. It must necessarily possess a strength equal to the material which it will replace.

B. The density should be equal to or only slightly higher than the material it is to replace.

C. The dimensional stability should be such that when used in the finished product, it will give satisfactory service. By this, shrinkage and swelling characteristics must be minimized.

D. The bending strength should approach that of solid lumber.

E. The machinability should be such that no grave problems will be encountered.

F. The gluability of the compositionboard should be as satisfactory as with solid lumber.

G. The screw-holding power should be sufficient so that, if required in the finished product, the strength of the assembly will not be sacrified.

H. Surface irregularities of the finished panel should be no more than those allowable with a lumber core construction. A 1/20″ cross veneer, used in conjunction with a 1/28″ face veneer, should not show any telegraphing of the individual chips. This may, however, vary with the end use of the product.

I. The wood composition board should be free from warpage tendencies.

J. The wood composition board should be of even density throughout.

Investigative Work

The decision of our organization to enter into the manufacture of wood composition board was made only after satisfactory results had been obtained from the previously listed tests. Preliminary investigative work was begun in the late 1940's and, at that time, the majority of such product were obained from European sources.

Three Swiss and German materials were evlauated by our technologists. One, called Novopan, consisted of a core made with resin bonded planer shavings. It was covered on both sides with a thin layer of specially prepared shavings of a relatively high resin content in order to give improved water resistance. A product of this type, under a different name, is now commercially available in this country.

The Harder process was unique in that the core and veneers were bonded into a complete panel in one operation. This material had an extremely high resin content and, as a result of the high density, was difficult to machine with ordinary woodworking tools.

Table 1.—RESULTS OF TESTS OF PROPERTIES OF 12 TYPES OF WOOD COMPOSITION BOARD.*

	Density	Retention of Swelling	Hardness	Screw-Holding Power
1. British Multi-Platen Type	54.3	0.1%	1933	413
2. Multi-Platen Type (U. S.)	52.0	0.1%	2125	605
3. Multi-Platen Type with Fine Surface (U. S.)	52.0	0.1%	1440	385
4. British Multi-Platen Type	50.4	0.1%	1446	313
5. Extruded (U. S.)	49.8	0.1%	720	394
6. Multi-Platen Type (U. S.)	48.0	0.1%	2212	487
7. Extruded (U. S.)	46.8	0.1%	430	54
8. Multi-Platen Type with Flake Surface (U. S.)	40.9	0.1%	620	160
9. Multi-Platen Type (U. S.)	40.5	1.0%	710	186
10. Swiss Multi-Platen Type	40.5	1.0%	1070	230
11. Extruded (U. S.)	38.3	0.5%	933	190
12. Swiss Multi-Platen Type	37.4	1.0%	862	189

*Lists materials tested in Figs. 2, 3, and 4 and shows results used in compiling graphs.

Another product, made by the Behr process, utilized residue from European birch and beech. Again, the high resin content was detrimental to the machinability of the material.

The possibilities of composition board from other matterials should not be ruled out. A Belgian product, introduced to this country several years ago by Jean Verbestel, of the Linex Company in Brussels, was made with the woody pulp from flax straw. Investigative work has been done during the past few years in the United States in which insulation board has been made with corn husks, peanut shells, and corn cobs.

At the same time our organization was investigating foreign processes, interested parties in the United States were developing processes which would be more suitable for the particular applications which were needed in this country. Many of these firms were contacted, samples obtained, and evaluations were made.

Physical Properties

The three major tests conducted on these materials were dimensional stability, hardness, and screw-holding power. The results of various samples are shown in Table 1.

Dimensional Stability: Dimensional stability was determined by veneering a ¾″ × 12″ × 12″ specimen of composition board core, using 1/20″ cross veneers and 1/28″ face veneers. The panel was then sanded, filled, sealed, scuff sanded, and given two coats of lacquer. Prior to finishing, the panel was conditioned at 6% moisture content. After finishing and the subsequent drying of the finish, the panel was measured over the entire surface for thickness. It was then subjected to 100° F. at 90% relative humidity until it reached equilibrium. After examining the panel, it was then redried to its original moisture content.

Those panels which retained less than 0.1% over the original thickness were considered to be acceptable for our particular use. Some retained 1% or more and were not considered desirable. Still others showed evidence of localized warpage, shrinkage, or swelling of the individual chips, and the appearance was definitely a detriment. One of the major disadvantages of a high retention of swelling is that it would pose a problem when that type of core is used with solid lumber bands around the edge. There would be too much variation in the retention rate between solid lumber and the composition board.

Fig. 2 illustrates the relationship between density and dimensional stability. Generally speaking, as the density of the product increases, this overall retention of swelling decreases. This can also be controlled by the use of a wax treatment to retard the moisture absorption; however, other characteristics are reduced proportionately.

Test results showed a definite relationship between moisture absorption, or retention of swelling, and specific gravity or density. It stands to reason that the better coated the individual chips are with a moisture retardant material such as resin adhesive, petro-

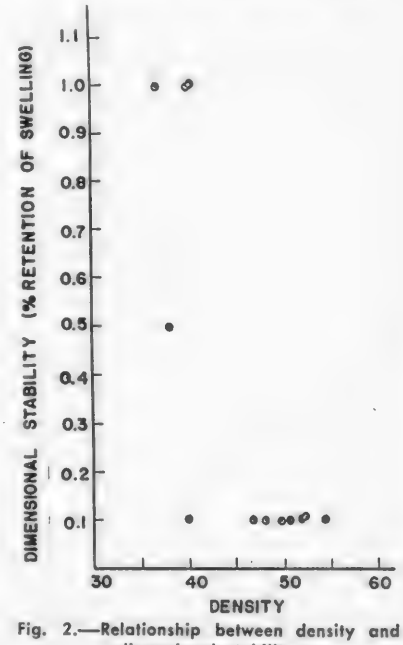

Fig. 2.—Relationship between density and dimensional stability.

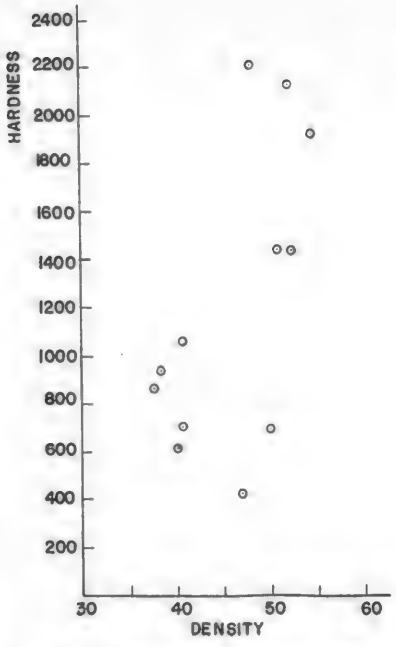

Fig. 3.—Relationship between density and hardness.

latum, or waxes, the more stable the finished product will tend to be.

It is our opinion that a multi-platen type composition board possesses many advantages. With the proper control, it has good dimensional stability, is flat, rigid, and strong. It can be machined or sanded with conventional woodworking equipment, and possesses good screw-holding properties. In trial operations, it was found that it veneered as easily as solid lumber cores and could be edge-glued with equal success.

Hardness: The hardness of the composition board was determined by measuring the force required to imbed a steel ball 0.444" in diameter to one-half its diameter into the specimen. This was done on a Riehle Universal Testing Machine with the standard equipment required for this test.

Some materials tested were found to be extremely brittle and no conclusive result could be obtained. However, others compared quite favorably to the solid lumber that we were currently using as a core material. One thing that came out of these tests was that if the moisture in the panel is not equalized at 6%, or if the chips are extremely wet prior to gluing, the product is more susceptible to cleavage during this test.

Fig. 3, shows the test results pointing out the relationship of density to hardness. The hardness test results were noticeably low in the low density samples and were somewhat higher in the high density samples.

Screw-Holding Power: For this particular test, veneered panels were drilled with a No. 30 drill to a depth of 5/8". The force was then measured which was required to withdraw a 3/4" No. 10 wood screw from this pilot hole. Various sizes of pilot holes and screws can be used but these were the sizes most commonly used for our particular type of construction. Tests were also conducted in which sheet metal screws were used in place of wood screws.

It was found that there was a noted increase in strength when the sheet metal screws were used. However, all types are not as readily available to make their use very practical at this time.

Fig. 4 shows the effect of density upon screw-holding power. The heavier samples tested showed a marked increase in the holding ability over the lower density samples.

Availability of Usable Waste

Once it was determined that the type of particle board required could be manufactured, a survey was undertaken to ascertain the quantity of usable waste that was available for the establishment of a plant to produce composition board.

It was decided that usable waste would consist of only that material from which a suitable size of chip could be obtained with which we could make a splinter-type board. This ruled out all sawdust and much of the shavings normally obtained in the manufacturing operations.

A staggering amount of material that could be used was found to exist. The type of waste considered included block waste, veneer trim, veneer clippings, veneer cores, and sawmill slabs. In this study it was found that from the standing tree, excluding all bark and stumpage, 31% was wasted in topping it. The waste from the log, as it is processed in the sawmill, amounts to 27%. In the rough line, 18% of the lumber is waste and the additional waste in planing and dimensioning brings the waste figure up to more than 88%. This leaves only 12% of the original tree in the finished product.

In the production of veneer, more than 22½% is lost in the core. Green end trim amounts to 6%. Green clipping is slightly more than 31%, with dry clipping waste being about 15½%. The remaining 25% is utilized in the finished product.

Of the usable waste, 33% of the green waste and 25% of the dry waste will be lost as fines in the drying, grinding, and screening operations. The fact still remains that, in our plant, each year we have 2300 tons of dry usable waste and 11,612 tons of green usable waste, converted to 8% M. C. This is an adequate amount

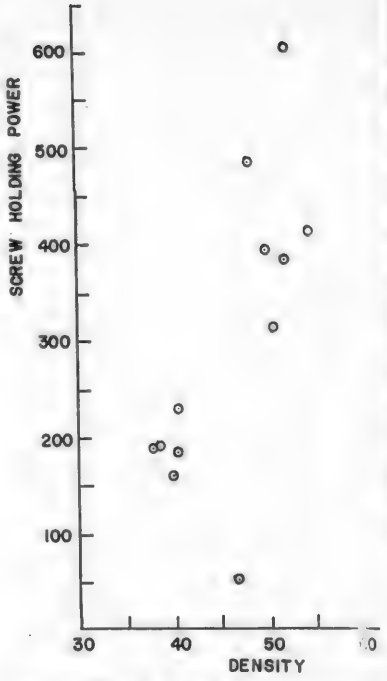

Fig. 4.—Effect of density upon screw-holding power.

of waste to operate a plant which, for producing a 3/4-inch, 45 lb. density board, will require 11.25 tons of 8% M. C. material per 8 hour shift. These waste figures are based on all of our operations, from logging in the woods through the manufacturing processes in the plant.

After the fines are removed from the 13,912 tons of waste, and approximately 7½% adhesive and extender are added, the potential for producing 10.503 tons of composition board still remains. As fuel, the value of wood waste has been calculated to be $6.24 per ton. Based on 30% heating value when compared to oil, and oil priced at $20.80 per ton, the utilization of waste in a particle board product is more than justified.

An investigation is currently underway by members of our organization to determine the feasibility of debarking the entire log in order to increase the amount of usable waste that could be made available. It has been learned that an excess of 10% bark in the finished product will necessitate the addition of a greater amount of resin binder, thereby increasing the density proportionately. Such an investigation might be further expanded by chipping even the tops of the trees, thereby utilizing the 31% now left in the woods.

Conclusion

Increased utilization of our timber resources by diversified harvesting is increasing the profitability of forest products. The development of wood composition board has made a tremen-

dous impact in the woodworking industry and it is up to all those whose livelihood is dependent upon this industry to see that it is developed to the utmost. Through an adequate means of evaluating a product, the user or potential user is in a position to exert considerable influence toward the development of the product.

Wood composition board is a means of conservation of forest products through more complete utilization. It must be accepted for what it is worth, and its worth is far greater than we know it by present day standards.

Discussion

Montgomery R. Childs (N. C. State College): Were unveneered and unsealed panels run as controls in the retention of swelling tests? If so, what were the comparative results?

Mr. Kelly: For our test, only panels which had been veneered were sealed and measured. We are currently making a comparative evaluation between veneered and unveneered specimens.

Lawrence McGee (N. C. State College): What are the screw holding powers of the various types of boards, i.e., extruded, batch-type, etc.?

Mr. Kelly: This question could have a range of answers as wide as the range of densities possible to obtain in the manufacture of particle board. The screw holding power is affected not only by density, but by particle size, orientation of the chips, etc.

Steve Preston (University of Michigan): Are all your tests of telegraphing conducted on a 5-ply construction?

William Burk (Poinsett Lumber Co.): We have made sample panels in both 3-ply and 5-ply construction for the telegraphing observations. However, in some types of board, we have found that 5-ply makes the panel somewhat more acceptable.

Mr. Preston: Was this measured in a quantitative way or by visual inspection?

Mr. Burk: Attempts were made to make a quantitative evaluation, but we found that visual inspection would suffice for our particular use.

Mr. Childs: Did you run full-size panels in your test work?

Mr. Kelly: Small-size panels, 14- by 14-inch, were made for laboratory work, but full-size panels were used in actual construction for a field test program.

L. E. Miller (Holly Hill Lumber Co.): Did you run tests before and after veneering on stiffness of extruded and multi-platen type boards?

Mr. Kelly: We tested both ways, but inasmuch as all of our construction is veneered, we resorted to veneered tests only.

Thomas Allen (The Lane Co): How many specimens did you test to get the screw holding power of the extrusion board?

Mr. Burk: This was wholly dependent upon the amount of material available for testing. In some cases this was as little as five withdrawals, but other specimens yielded as many as 100.

Utilization of Hardwood Waste[1]

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Outlines the present possibilities of hardwood waste utilization and gives brief outlook for future. Describes developments in the processing equipment and transportation fields which have helped advance toward full-use goal. Progress to date has been result of cooperative effort of the hardboard, hardwood, and waste processing equipment industries.

AMAZING TECHNOLOGICAL ADVANCES in the field of hardwood waste utilization have been made in the past year. In spite of these advances, we are only at the threshold of developments that will revolutionize the economics of all branches of the highly diversified wood using industry.

The objective of this paper is to outline the present possibilities of hardwood waste processing, and the huge efforts that were necessary by other industries to bring them about—particularly in the field of processing equipment and transportation.

Today's hardboard industry resulted from the efforts of one scientist, William H. Mason, to resolve a use for the huge quantities of pine sawmill waste prevalent in Mississippi in the 1920's during the heyday of virgin pine. All of the raw material for our first few operating years consisted of slab waste in chip form. The cutting out of timber stands and decline of the large pine mills dictated a transition to pine pulpwood, of which an abundant supply was available.

As we mark completion of a 25-year cycle in this branch of the pulp industry, we are returning to use of industrial by-product waste, with a lessened drain on small trees that will support industries requiring larger diameter sizes. During the intervening years, utilization of limited species of hardwood pulpwood was attained. This brings us up to specific developments in usage of waste hardwoods in a form other than pulpwood—chip wood processed from waste of the hardwood industry.

Key to Utilization

Prior to 1955, progress had been achieved in utilization of hardwoods in pulpwood form, but little effort had been made in industrial waste utilization in the South in any field other than pine. The widely diversified hardwood species processed by the sawmill, veneer, box, and other hardwood industries presented a serious obstacle to overcome in considering economical processing of hardwood waste. It was apparent that the key to hardwood waste utilization, to any degree, lay in versatility of species usage by any potential purchaser.

Having recognized this realistic situation, the widest possible spread in hardwood species utility was sought. When the ultimate of handling all native hardwood species was attained, through processing technology, large scale hardwood waste in the form of industrial by-products could be utilized.

In setting up an industrial waste program designed for the hardwood using industry, it became apparent that the following fundamental factors were essential for the program to be economically feasible for both the seller and the buyer:

a. Large volume for the buyer.
b. Workable processing equipment within the economic means of the wide range and size of hardwood plants necessary to generate the needed volume.

[1] Presented at meeting of the Mid-South Section, FPRS, November 7–8, 1955 in Memphis, Tenn.

c. Economical handling and transportation.

In studying the volume factor, our findings were that supply sources could be divided roughly into three categories—which separation would synchronize the usage limitations of the buyer to the apparent availability of processing equipment for each category. These groups were: hardwood sawmill industry, hardwood box industry and other industry generating like shape and form of waste, and veneer industry.

Processing Equipment

In the equipment field, it was found that log debarking and chipping equipment developed for Southern pine mills was adaptable in most instances to hardwood mills. At least it was sufficiently encouraging so it was felt that opening a hardwood chip market would furnish the incentive for the equipment manufacturers to direct special emphasis in this direction.

In the hardwood box industry, the uniform chipping of odd-size dry lumber trim previously had been an insurmountable obstacle for the equipment people. Major effort by equipment engineers has resolved this problem to the point that most forms of lumber trim and residue can no longer be considered waste, but rather a potential revenue.

In the veneer field, findings on waste processing potential were more favorable than in any other field—from the standpoint of conservation, income for the seller, and availability of low cost processing equipment that would produce a desired size chip. Assurance of a dependable waste chip market quickly facilitated assembly line production of equipment readily acceptable by veneer plants. It is of interest to note that only about four months elapsed between joint experiments conducted with the chipping equipment industry and acceptance of chipping installations by the veneer industry. It is particularly recognized by this section of the hardwood using industry that 1955 was a year of revolutionary development—in that waste sales have become an economic factor ranking in some plants almost equal to income from finished product.

An interesting discovery in the veneer industry is the fact that up to 50 per cent of the original log was potentially recoverable for chip wood, provided workable processing equipment was available. Previously, only the veneer core had been accepted as salable waste. If the ultimate of utilization of the entire 50 per cent bark-free waste in each log could be attained, then the waste recovered from veneer logs would exceed the chip wood recovery of the original tree, had the tree been marketed at the earlier pulpwood diameter stage of growth. Hardly a more attractive incentive to waste utilization could be found than reducing the cutting of pulpwood size trees and at the same time realizing the same yield in chip wood from that tree at a later stage of growth.

Today in the veneer industry many plants have brought their waste recovery to about 40 per cent of the veneer log through sale of cores and chipping of sheet roundup and finished product trim. About the only non-salable portions of a veneer log in some plants, excluding bark, are the log cut-offs or so-called "lily pads." Even these minor portions, which present a disposal problem in most plants, are coming in for attention. Experiments underway give promise that the industry soon may be processing these odds and ends into salable chips.

The waste factor in the hardwood sawmill and lumber industry is almost equally attractive from a revenue and overall conservation standpoint. Without delving into specific economics of this section of the hardwood industry, it can be stated that the possibility of waste processing can hardly afford to be overlooked by the majority of plants in the Mid-South area.

In the vital field of handling and transportation of chipped waste, much credit must be given to the railroad industry for their cooperation and farsightedness in providing sizable new special equipment found necessary if the overall program was to be successful. In discussing planning for large scale waste utilization with officials of three major carriers, they quickly recognized the need for special equipment to provide both acceptable transportation rates and handling costs. They were quick to grasp the conservation aspects of such a program and the opportunity afforded for industrial expansion with lessened drain on available raw material reserves. Accordingly, they assigned their engineering divisions the task of developing a usable car.

The car had to provide service features covering a multitude of factors affecting performance, such as a wide variety of chip sizes, species, moisture content, bulk density, etc. After many months of experimenting, they developed a workable self-clearing car through modification of some of their existing equipment. Today these cars bearing the insignia "waste chip loading" are under construction in sizable quantities, with many already in use.

Future Outlook

Now it can truly be said that waste utilization in the hardwood industry is not the theory of tomorrow, but the fact of today. But what of tomorrow? Foreseen in the future are gigantic additional strides. The hardboard industry will pursue this program to every extent that sound economics will permit. Experience with the hardwood industry leads to the belief that they also will continue past coperative efforts toward a goal of complete utilization of present waste.

It is vitally important that all sections of the hardwood industry should encourage the waste processing equipment industry toward further research and development in their field. Their efforts have been of immeasurable value in bringing utilization to its present stages of development.

Use of Preservatives in Board Products[1]

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Outlines the present position and problems of the fiberboard industry with respect to preservative treatment. The following questions are raised and partially answered: Has the ideal preservative, both from the effective and economical point of view, been discovered? What is the most effective means of introducing a chemical preservative into fiberboard? Is there proof of the desirable level of treatment necessary to assure protection under actual use conditions?

SINCE ITS BEGINNING in 1914, the wood fiber insulation board industry has grown until today it ranks as an important supplier of building material.

At present some 1.3 million tons of fiber insulation board is produced in this country annually. This volume includes fiberboard products used for exterior sheathing and roofing and for interior wall and ceiling covering. The industry still has its greatest period of growth ahead. The now-famous Stanford report estimates building board production to reach an annual 3.6 million tons by 1975. There will be improvements in board manufacture and there will be changes in end uses of fiberboard. New uses are and will be devised for the increased production. Particularly is this true in the use of more rigid and higher density fiberboards. While the original emphasis was on insulation value, other qualities for specific use functions are assuming greater importance. The recent uses of rigid fiber insulation boards for engineered structural units, as in roof deck or the Lu–Re–Co panel construction, and proposed future applications are indicative of this trend.

One of the problems that faces the industry, particularly in view of the changing use pattern of this material, is to maintain and increase the practical service life. There are several approaches to the problem and one, of course, is preservative treatment.

The fiber insulation board industry, although employing various preservatives for several years, may technically still be considered in its infancy as far as proper preservative treatment is concerned. Here is a product made from fibers, yet put together in a way so as to rearrange the fibers and change the end product from the original raw material—wood in most cases. Thus, the board produced may and does act considerably different from wood. In addition to the rearrangement of the fibers, certain additives tend to create other conditions foreign to the natural product.

These facts, in addition to the peculiar circumstances governing actual production of fiber insulation board, make it impractical (even impossible) to apply the same techniques used successfully in the treatment of wood to the treatment of fiberboard. Considerable progress has been made in the actual introduction of presently available preservative chemicals into the system, although there is some doubt as to the progress made in keeping the preservative in the board. Some of the technical aspects of this problem will be discussed later in this paper.

Perhaps more important from a future standpoint is the problem which involves knowledge of the extent of treatment necessary for adequate protection under practical field conditions. It is believed that information is not now available as to the amount of a given preservative needed to assure adequate protection of fiberboard when such board is properly used and maintained. Extensive surveys to determine the conditions under which deterioration occurs in the field have not been made. Consequently, tests simulating these conditions have not been devised and various levels of treatment needed to protect the board have not been established.

Just as the techniques for getting the preservative chemical into wood cannot be successfully used to introduce the same material into fiberboard, so the tests designed to prove or disprove the reliability of treatment for wood should not be used to establish the same proofs for fiberboard.

Present Testing Techniques

There are several organizations which are presently testing fiberboard to determine its resistance to decay and termite attack either in its natural state or treated at various levels with toxic chemicals. There is even a so called "standard" treatment recommended to render this material immune to attack.

The usual approach to testing in the laboratory is to subject the board to one of several organisms under conditions known as soil-block or soil burial tests and observe the presence of fungal growth and the resultant weight loss of the board. Both of these tests were designed to test the effectiveness of preservative treatment of solid wood, particularly wood to be used in or near soil. This is a very severe test for a material since it presents almost ideal conditions for fungus growth.

While these tests have been carried over from wood to fiberboard, it is not wise to interpret the results in the same magnitude. The soil-block and soil burial tests serve as an adequate means of comparing the relative effectiveness of different toxic chemicals under the test conditions, but are actually a poor indication of a given treatment under different use conditions. Yet a great deal of time and money has been spent and is still being spent on this approach due to a lack of a more applicable technique.

Attempts have been made to create a more realistic approach to this particular problem. Several of the preservative manufacturers have gone from the "testing-in-glass" technique to field testing. My company and several others have cooperated in these ventures from time to time. Again borrowing from experience with treated wood, this approach would parallel that of stake plots or field tests with posts and poles. This is certainly a noble attempt at clarification of the problem, but from a study of the data available it is seen that the results have been very erratic and the recommendations growing out of these tests are based on poor evidence.

[1] Presented at Session III, Wood Preservation, FPRS Tenth National Meeting, June 4–7, 1956, Asheville, N. C.

Author: W. L. Meek holds B.S. from [illegible] U., M.S. from U. of Minnesota. He was a member of Forestry Department Staff at U. of Illinois before accepting his present position.

More recently, laboratory tests constructed on a "no medium" basis and also on an exposure to an infected material away from soil have been devised. These would seem to be a more realistic approach to the problem.

Three Problems of Preservation of Fiberboard

In an attempt to define the basic problems in the preservation of fiberboard, the following three questions are raised and at least partially answerd.

Has the most effective and economical preservative been discovered?

The list of chemicals used in an attempt to render fiberboard free from attack by destructive organisms closely parallels that found for solid wood. In addition to coal tar and petroleum derivatives (including asphalt), metallic arsenic compounds were among the first compounds used to preserve fiberboard. Records disclose patents regarding the use of zinc-meta-arsenite filed in 1928 and 1930. In 1930 a patent was filed covering the use of ferric arsenite. By the middle 1930's, investigations of chlorinated phenols were underway. As in the preservation of wood, this later approach has today resolved itself to the use of pentachlorophenol or its salts for fiberboard. Penta, and in particular, copper pentachlorophenate, is widely used today in the fiberboard industry as a fungicidal preservative. Other toxic chemicals have been used or suggested from time to time. Studies have been conducted both in Sweden and in this country with 8-hydroxyquinoline, particularly as a mold and decay preventative during the storage of wet lap pulp.

Each of the previously mentioned chemicals has enjoyed some success and some acceptance by the industry. The old question of the necessary degree of treatment, however, remains as a strong deterrent to the absolute acceptance of any of these chemicals.

Actually, from a practical point of view many uses of wood require no additional preservative treatment, others require a short term or superficial treatment, still others require a long life treatment. Under normal use conditions, wood studding, rafters, joists, interior millwork, etc., require no preservation. It is doubtful from an economical return basis that these construction members will ever be treated on a wide-scale basis.

On the other hand, wooden window sashes are practically all given a superficial surface treatment which under normal use conditions quite adequately protects these members from decay or stain organisms — particularly during the early stages of construction when they may be exposed to unusually high humidities. Lower plate members of slab construction, posts, poles, and piling are often treated to protect these members from the severest conditions of decay. A similar diversification of use exists with fiberboard. It would seem reasonable to approach the problem from this angle.

Furthermore, both fungi and insects require certain conditions before becoming active. The proper combination of moisture, temperature, air, and food supply must exist before destructive organisms can function. Controlling any or all of these conditions serves as effective "preservation".

No doubt, the surest means of preservation is to poison the food supply. Of nearly equal importance is the control or reduction of moisture pickup. Here fiberboard has an advantage over wood since by the very nature of its manufacturing process, a means is provided for introduction of sizing materials.

Furthermore, an excellent and practical means of effecting preservation is to follow proper construction techniques. Few complaints have been received which indicate that fiberboard failed when it was installed and maintained according to recommended building methods.

It is believed that the question of the ideal preservative can be answered only by continued investigation of present and new methods of preservation by chemical manufacturers in cooperation with institutional organizations and fiberboard producers.

What is the most effective means of introducing a chemical preservative into fiberboard?

The manufacture of fiberboard is related to the manufacture of paper. The raw material is first reduced to fibrous material and then recombined to form a mat which is pressed and dried to form the final board. The first insulation board made in this country was formed on a machine designed to utilize flax spinner waste. With some minor changes, this same machine was used to produce the early wood fiber insulation board.

This early board machine consisted of one wire cylinder which picked up pulp and layed it out on a Fourdrinier wire running on top. The sheets were cut to size with a butcher knife. Today fiberboard is formed either on modified Fourdrinier machines or on various types of cylinder machines. No matter what process is used to form the board, the stock is prepared in an "open" water system which precludes the use of pressure or vacuum systems for introducing the preservative. Also, since water is the carrier throughout the system, there is the major problem of keeping the preservative in the system and in the board once the water is removed.

The procedure presently used is to introduce the preservative chemical into the system just prior to the formation stage and depend on the dispersed particles to find and cling to fibers. The procedure is not always successful; a retention of 80 per cent is considered high. Many variables enter into this method of introduction and results are far from consistent. Any system involving thousands of gallons of water, the temperature of which may vary with the seasons, and a natural product such as wood fiber, which has character and quality that may vary with nature's whims, is difficult to control within the narrow limits sometimes necessary for best results. Preservative manufacturers and their distributors have spent considerable time developing processes for introducing toxicants into such a complex system.

It is believed when the other questions concerning preservative treatment of fiberboard are answered, that the preservative manufacturers together with the fiberboard producers can work out better methods of introducting toxicants into fiberboard.

Is there proof of the desirable level of treatment needed to assure protection under actual use conditions?

This is a many-sided question and a positive answer for one phase may change to a negative answer for another phase. First, it must be recognized that end use alone dictates the necessity for treatment to prevent deterioration from decay. In many present uses, fiberboard is not subjected to conditions conducive for deterioration. Board used on the interiors of well-built houses or in areas where temperature and moisture conditions will not reach levels necessary to support fungal growth need not be treated. It is poor economics to spend money to treat all production slated for interior use just to protect those few instances when either unusual circumstances or poor installation techniques result in loss due to deterioration.

However, some present uses, and without a doubt many future uses, dictate that treatment be given of a degree concordant with conditions encountered during normal use. As fiberboard, particularly of the higher density ranges, moves into more exposed areas and closer to the ground, it must be protected from deteriorating micro-organisms. It is these uses and the actual conditions which exist under these circumstances that will deter-

mine what to treat with and how much to use. It is of extreme interest o learn that under certain conditions mild treatment may even stimulate certain fungal growth.

It is imperative that ample and accurate surveys be conducted which will ead to the knowledge necessary to nswer this most important question. The industry will not accept anything less than factual information gained rom and based on this type of study. Once the conditions have been learned under which deterioration occurs in ctual use as well as the microorganisms which cause this deterioration, then simulated test procedures can be established to duplicate these circumstances. From available information it appears that the Insulation Board Institute, the U.S. Forest Products Laboratory, and the University of Minnesota are aware of these facts and are attempting to answer these questions. It is hoped that other research institutions and that manufacturers and distributors of preservative chemicals are also aware and willing to cooperate in finding the answers.

Conclusion

An attempt has been made to briefly describe the fiberboard industry's problems concerning preservative treatment. This is a growing, changing industry and proper preservation is one of the many problems which confront such a situation. The answers which would best benefit both the producer and the eventual user are being sought and progress has been made. This is shown to be true by the very fact that the industry is aware of the problem.

Before a complete understanding and acceptance of any preservative program can be accomplished, assurance must be given that: 1) the proper preservative is available, 2) the proper levels of treatment under use conditions are known, 3) a suitable method of introduction and retention has been devised, and 4) suitable tests are available to assure compliance with the above conditions.

Acknowledgement

The writer wishes to acknowledge the assistance of Fred Battell, Research Librarian, Minnesota and Ontario Paper Company, who prepared the attached bibliography. Also, thanks are due to Dr. D. W. French of the Department of Plant Pathology and Botany, Institute of Agriculture, University of Minnesota, for his aid in preparing this paper.

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Discussion

A. F. Verrall (Southern Forest Experiment Station): Different exposure tests should be adopted since soil burial tests are too severe for certain types of treated material. Samples should be kept off the ground in insulation board tests.

Mr. Meek: Tests are being undertaken along these lines. Insulation boards could be placed next to wood in which rot is started.

Mr. Verrall: Tests should include some in which hazard is created by rain seepage.

Mr. Meek: Dr. D. W. French, University of Minnesota pathologist, is investigating several non-soil medium testing procedures. There are numerous possible approaches which simulate actual use conditions.

Ira Hatfield (Wood Treating Chemical Co.): You mentioned that not all wood products require the same level of preservative treatment since end uses of wood vary. You then said, I believe, that by the same token, not all insulation or fiberboard materials require the same treatment. Granting this is true, can fiberboard manufacturers economically have stocks of treated and untreated stocks and sell treated board according to its end use?

Mr. Meek: Under present conditions of production and distribution, this would not work out easily. Lack of inventory is a serious drawback to this approach. However, when such questions as were asked in the paper are answered, we will have a better idea of the necessity of such a plan. If it is then considered necessary to treat at various lvels, I am certain the industry would work out a distribution system.

Eldon Behr (Chapman Chemical Co.): Complaints of home owners as to damage of insulation board may be more numerous than one thinks, as some boards are or were made without a name on them. If a house wall is removed and insulating sheathing is found to be defective (damaged by termites), the user, not knowing who the manufacturer is, does not know to whom he can complain.

Mr. Meek: It is my understanding that most manufacturers label their products. This is particularly true of sheathing. We certainly do.

A New Method of Applying Pentachlorophenol to Wood in Place[1]

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Describes a new form of penta-petroleum solution which is based on a thickened emulsion. When applied to wood in use, the solution functions as a reservoir, gradually breaking down at a rate in keeping with the adsorption by the wood. Various applications are outlined and results of penetration studies reported on the in-line treatment of utility poles and 2- by 8-inch structural timber.

FOR A NUMBER OF YEARS there has been considerable interest and effort in finding a means of effectively applying an established wood preservative to wood in use and/or in existing structures. The records bear testimony to this challenge.

Some of the more common methods presently employed range from brush and spray applications (5)[2] to the boring of holes at strategic points in structural members and low-pressure impregnation of the immediately adjacent areas. Reservoir cups screwed into similar holes and periodically filled with preservative solution as a means for obtaining treatment as a result of diffusion or capillary flow serves as another example of these efforts. Admittedly, a degree of protection is afforded by any of these methods if the job is well done; in some instances the results are quite effective, although the cost of application is often unrealistically high.

In keeping with this constant research effort, it was inevitable that as an outgrowth of this varied experimentation a method or process would be developed which would combine low material cost, ease of application, and highly effective results when applied to wood in place. The thickened emulsion form of a penta-petroleum solution described herein is receiving wide interest as perhaps the best answer to this problem so far developed.

U. S. Patent #2,708,640 (Wayne K. Davis—Oakland, California) of May 17, 1955 (4), describes a new toxic coating composition and method of applying the composition to the wood. The coating contains the same highly efficient wood preservative, pentachlorophenol, which is now widely used for the pressure and hot and cold full-length treatment of poles and other forest products. The Davis patent, however, covers an entirely new aspect of formulation and technique of wood preservation for application to wood in place.

The penta-petroleum emulsion, Woodtreat,[3, 4] is an oil-in-water emu-

[1] Presented at Session III, Wood Preservation, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] Numbers in parentheses refer to literature cited.

The Author: R. G. Van Allen is a wood utilization graduate of Purdue U., did advanced work in organic chemistry at Washington U., and joined Wood Treating Chemicals Co., in 1950. He is a member of the FPRS Wood Preservation Division.

[3] Trade Mark Reg., Wood Treating Chemicals Co., St. Louis, Mo.

[4] In order to avoid writing out the description of this product and the results obtained with its use each time reference is made to it, the trade name Woodtreat will be used to conserve space.

ion. The material is applied as a semi-stable, highly viscous, self sustaining emulsion to form a heavy coating ranging up to one inch in thickness over wood to be treated. This coating subsequently hardens at its outer surface, forming a protective film. Functioning as a reservoir, the emulsion gradually breaks down at a rate in keeping with the absorption of the penetrating phase by the wood.

Historically, the use of emulsions in the field of wood preservation has been limited. Hunt and Garratt (7) indicate that as early as 1879, a combination of zinc chloride and glue was tested, and mixtures of creosote and zinc chloride have been used. Undoubtedly tests with emulsions have been sparse because of the complex structure of wood and its filtering action on dispersed particles.

Howald (6) describes a water-in-oil zinc chloride petroleum emulsion designed for pressure impregnation of timbers. These dispersions were made mechanically by pumping a mixture of asphaltic residuum, distillate fuel oils, and a concentrated zinc chloride solution through an emulsion valve under high pressure (about 2000 pounds per square inch) at 170° F. It was claimed that an emulsion so formed was of sufficient fineness and stability for purposes of wood impregnation. The purpose of such an emulsion was to take advantage of those desirable characteristics which are associated with petroleum carriers or oil-borne wood preservatives—the reduction of leaching and increased water repellency.

This earlier work indicated the process described by Howald had some degree of merit although certain limitations attributed to emulsion stability existed and there were questions as to the state of the active components once introduced into the wood. Other specific references dealing with emulsions as related to wood preservation refer to operational difficulties at pressure treating plants (9).

More recently wax emulsions containing the water soluble sodium pentachlorophenate have been given consideration for such applications as end coatings and for the prevention of checking in lumber, timbers, and boat decking. None of the illustrations cited made use of an emulsion as a bodying agent which also functioned as a method of application.

Emulsion Mechanism: Woodtreat contains 87% by weight of an aromatic petroleum solvent containing 5% pentachlorophenol. The balance (13%) of the composition is emulsion stabilizers and water. The normal concept of emulsions might lead one to think that the emulsifiers added to the oil would render it re-wettable and therefore leachable from wood subsequently treated therewith. This is not the case, however, as the role of the emulsifier is partially supplanted by the manufacturing procedure, hence only certain stabilizing agents are used in the water phase.

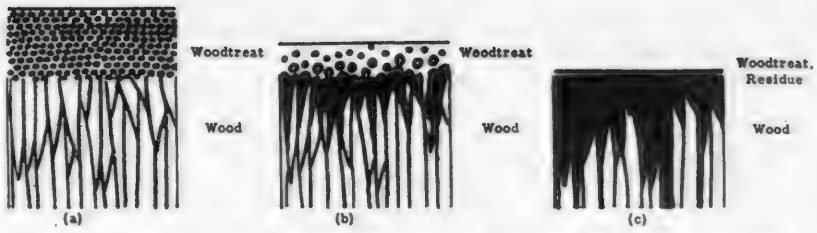

Fig. 1.—Diagrammatic illustration of proposed mechanism by which Woodtreat penetrates wood.

In view of the fact that this material is an oil-in-water emulsion which is bodied (viscosity increased) to the degree that it may be troweled onto a vertical wooden surface in coatings up to an inch in thickness, it might be difficult to envision that no chemical change has been made in the oil phase or the penta-petroleum mixture. Keeping in mind that the oil phase is the internal or dispersed phase, the concept is explained clearly by Sutheim (10):

> "The viscosity of an emulsion is dictated by three main factors—the viscosity of the external phase, the phase-volume ratio, and the particle size. It is, however, rather independent of viscosity of the internal phase. This may be surprising but if you consider that the dispersed droplets are thoroughly isolated by the enveloping film, you will understand that the viscosity of what is inside the envelope can hardly influence the viscosity of the outside. In fact, from thin liquids like benzene, up to semi-solids like rubber hydrocarbons, oil-in-water emulsions can be made which have practically the same viscosity, provided that the factors having a real influence on the viscosity are kept the same."

With the viscosity of the external phase or water phase the decisive factor and one that can be easily controlled, the mechanism of Woodtreat becomes more easily understood. For oil-in-water emulsions there are a number of swelling or bodying agents which impart high viscosity at low concentrations. Thus we can obtain almost any desired consistency of the external phase without altering the over-all properties of the emulsion. Hydrophilic colloids make up the major portion of the bodying agents which might be used. The stable composition of Woodtreat relies on a major amount of chemically unmodified oil and penta (87%) dispersed in a minimum amount of water which contains the necessary protective colloids and stabilizers.

Oil Phase Penetration: The use of penetrating coating compositions is by no means a new method of treatment. For years there has been a demand for a method of in-line treatment of utility poles and to this end some proprietary materials have, when applied properly, afforded extended service to the pole (8). In the main, these materials have been paste materials containing pentachlorophenol (2), creosote, or a combination of water-soluble salts in an asphaltic base material (1).

One of the principal shortcomings of the more viscous materials has been the fact that to gain the high viscosity, actual modification of the penetrating phase has often occurred. Metallic soaps, bentonite, and colloidal silica are a few of the basic materials incorporated in these products. Colloidal silica, for example, will absorb and hold in paste form large quantities of oil. When applied to a utility pole, however, the retentive power of the colloidal silica still exists, and as a result little of the preservative solution is released for diffusion into the wood. Here the preservative coating functions as a mechanical barrier to agents of deterioration, but it does not always give the desired interior protection to the item to which the coating was applied.

In contrast, the emulsion principle previously discussed in connection with Woodtreat affords unrestricted movement of the oil phase. As the water evaporates from the surface of the coating, the droplets of dispersed preservative solution coalesce and the liquid diffuses into the wood. Penetration is obtained in a relatively short period of time, the depth depending upon the moisture content and condition of the wood. At the same time, a protective film is formed by the water-phase components, which minimizes evaporation of the oil carrier and helps keep the emulsion coating in place.

Fig. 1 diagramatically illustrates the proposed mechanism for the oil-phase

movement. Laboratory tests have indicated that the preservative portion of Woodtreat penetrates wood of high moisture content as well as seasoned wood, although when the moisture is above fiber saturation, the absorption appears to take place at a slower rate. A possible explanation for this phenomenon might be that as the water is evaporated from the surface of the emulsion, some of this loss is compensated for by movement of water from the wood into the emulsion's continuous water phase, thus replacing that lost through evaporation or simply increasing the volume of the continuous phase. No data have been obtained as yet to substantiate this latter postulation although some phenomenon does function to allow penetration of wood containing water above the fiber saturation point.

Emulsion Applications: Davis (4) has utilized a bodied penta-petroleum emulsion in the pest control field for several years. As a result, a certain amount of application and service data covering this application existed, although specific performance data were not available.

During the subsequent development of a commercial product, application information for treatment of timbers in place as well as for other purposes was an essential step in the product's development. In addition to further development work leading to the use of such a product for the pest control field and/or for the treatment of existing structures, ground work has been laid for the utilization of Woodtreat for the following: in-line treatment of utility poles; ground-line treatment of re-set utility poles to provide soil sterilization in the new location; treatment of pole butts when new or higher ground lines are established; treatment of woodpecker holes and tops of standing poles; retreatment of salvaged poles, crossarms, and timbers; treatment of new holes and gains in poles and crossarms; and treatment of field cuts made in new, treated timbers and piling.

Of this potential market, the in-line treatment of utility poles and the treatment of existing structures afford the two extreme conditions where effectual results might be evaluated. For this reason it is the scope of this paper to present test data which would indicate the value of this new coating composition as well as the efficiency of such an application in relation to these specific uses.

Laboratory and Field Tests In-Line Treatment of Utility Poles

For the ground-line treatment of poles, a rather important property of emulsion-type formulations is their minimum loss due to soil penetration. After one month's exposure in open holes, as much as 90% of the emulsion remained intact. In view of this property of the coating, theoretically the wrapping or bandaging of poles after a Woodtreat ground-line treatment should not be necessary. Actual tests indicate this to be the case. Some ground-line penetration to sterilize the soil probably has a beneficial effect, but by comparison with the usual penta-petroleum solutions, it appears that the Woodtreat formula will hold the preservative ingredients at the wood surface long enough to do a superior job of penetration and loading of the coated wood with the preservative.

Utilities maintaining a large or small plant should be seriously concerned with the increased costs of replacing poles in line. The vulnerable point for most poles is the ground line where decay and, to a lesser degree, termites cause failure, although the rest of the pole may be in condition for many more years' service (3, 8). The initial pressure or full-length treatment of poles with penta or creosote in accordance with present standards is a guarantee of extended service life for new poles. However, there are now many treated utility poles that were installed in the 1930's that are perhaps beginning to approach the end of their predicted service life and which should be critically inspected. Pole line inspection provides an excellent immediate means of checking the condition of an individual pole. If these inspection reports are evaluated year after year, a "booster" treatment can be provided for any series or group of poles where decay failures at the ground line are beginning to show up prominently in the records. Many poles will, of course, be removed for causes other than decay. However, where the inspection reveals incipient decay at the ground line, the obvious answer to this problem, and to postpone the costly pole replacement, is an excellent and effective re-treatment of the pole at the ground line and one that can be done easily and economically.

The portion of this report dealing with poles covers only the initial test results on ground-line applications of the emulsion.

Ground-Line Test Treating Procedure: In order to determine the effectiveness of Woodtreat for the groundline treatment of standing poles as well as to develop information on the proper application technique, the following field testing was conducted at St. Louis from mid-September through early November 1955. Quantitative analyses of the borings were finished by mid-December.

Matched untreated Western red cedar pole stubs 5 to 6 feet in length and unmatched creosoted Southern pine stubs were used in this test. These pole stubs were from a local Union Electric Company yard and were from poles that had been in service for an undetermined number of years and then removed for causes other than decay failure. The cedars had originally been butt-treated but the butts were not included in this test nor were the original creosote retentions known for the Southern pine poles.

All pole stubs were in place in the ground by October 1 and back-filled. They were then allowed to come to an approximate equilibrium with the soil moisture as no emulsion application was made until October 14. Weather Bureau statistics for the St. Louis area for that period were as follows, showing rain in inches:

October 1	--	October 8	.03
October 2	--	October 9	--
October 3	Trace	October 10	--
October 4	.26	October 11	.03
October 5	.62	October 12	.23
October 6	.27	October 13	--
October 7	Trace	October 14	--

The fact that the pole stubs were placed on the side of a hill would perhaps have provided good drainage under different conditions, but the recent disturbed soil seemed to trap the water in mud holes around each pole. The rainfall figures are given to indicate that the results obtained were not under ideal conditions or with dry wood; the loosely packed soil readily transferred the rainwater to the stubs. The results hereafter reported show a considerable difference in results below the ground line versus borings taken above the ground line. That is another indication that the poles had taken up considerable moisture from the muddy ground.

In each row there was one section from the same cedar poles A, B, C, or D; the pine poles were not matched. Whether there was a higher or lower average moisture content at the ground line and below than actual poles in this service area at the same date was undetermined. However, for the purposes of testing, the conditions approximated actual service sufficiently so that the results are significant.

There were 24 pole sections placed in the ground—four Western red cedar and two creosoted Southern pine in four rows with the pine at the bottom. The October 14 applications were as follows:

1. Four cedar and two creosoted pine stubs were treated with two gal-

Fig. 2.—As Woodtreat was being applied Oct. 14, 1955.

Fig. 3.—Ten days after Woodtreat application.

lons each of Woodtreat and back-filled immediately.

2. Four cedar and two creosoted pine stubs were treated with two gallons each of Woodtreat and were back-filled later after the oil-bearing solution dissipated from the surface of the poles.

3. Four cedar and two creosoted pine stubs were treated with two gallons each of Woodtreat, wrapped with polyethylene, and then back-filled immediately.

4. Four cedar and two creosoted pine stubs were treated with two gallons of 5% penta-petroleum solution referred to as "B Wood Preservative" and back-filled immediately.

This treatment was carried out in order that each of four matching pole stubs from cedar poles A, B, C, and D was treated by the above four methods so that comparisons could be made using wood from the same pole. The actual treatment preparations corresponding to recommended standard field practice were as follows:

1. By means of a 16-inch drain spade, a trough was dug out around the pole section approximately 12 to 16 inches deep and 3 to 5 inches wide at the ground-line level. This was done by pressing the spade down along the pole and pressing the earth away from the pole surface without removing any of the loosely back-filled earth.

2. The Woodtreat was applied with a trowel[5] to a thickness of ¼ to ½ inch with all checks and splits carefully filled or smoothed over. This band of preservative coating at the pole surface extended about 24 inches above the ground line and to the bottom of the holes or troughs. The amount applied in this manner being difficult to control, any balance of the two gallons was poured into the hole and spread evenly.

3. The two gallons of the "B Wood Preservative", using a modified sprinkling can, were poured against the pole stubs about 1½ feet above the ground line and the preservative allowed to run down into the trough. The penta-petroleum solution was poured slowly around the pole so that it was directed into the checks and so that the trench did not overflow.

Fig. 2 shows the four lines of pole stubs on the side of the hill or slope as the treatment applications were in progress. Fig. 3 shows the pole stubs about ten days after the application. Fig. 4 is a close-up of the freshly applied Woodtreat, and Fig. 5 shows the coating reduced to a thin surface film about ten days later.

Ground-Line Test Treating Results—Untreated Western Red Cedar: All Western red cedar pole stubs in this test were bored one month after treatment. Twelve borings evenly spaced around the pole and taken to avoid checks or splits were obtained at the ground line; 10 to 12 inches above grade, and 10 to 12 inches below the ground line. (A total of 36 borings for each pole stub). Composite samples of the 12 borings at each level and at given depths from the surface were made and then analyzed for penta content at the first half inch in some cases, at the second half inch in other cases, and/or both at the first and second half inches respectively as per results reported in Table 1. A total of 72 analyses were made on the cedar by the lime ignition method (AWPA Standard A5-54).

Blank borings were analyzed prior to the treatment to learn whether these poles had been treated. Since negative chloride readings were obtained, it was a reasonable assumption that the poles had not been treated. The four matched stubs from each of the poles A, B, C, and D gave a fair comparison of the composite results obtained by each method.

The readings vary between the poles series A, B, C, and D due to the depth of the sapwood, but generally they are in the same order with regard to back-filling immediately vs. delayed back-filling and/or wrapping, and also the "B Wood Preservative" type application. The averages at the half-inch level of 0.753, 0.920, and 0.598 pound of penta per cubic foot of wood with all of the emulsion applications are well above the minimum retentions of 0.50 pound of penta required

[5] Later work shows a thin wooden paddle is better than a trowel.

Fig. 4.—Close-up of Woodtreat immediately after trowel application.

Fig. 5.—Close-up of Woodtreat ten days after application.

in Standard TD-100 of the Edison Electrical Institute for full length hot and cold submersion processes. Incidentally, that retention is the standard for the *incised* butt sections of cedar poles, and the pole stubs or sections in this emulsion application test were not incised.

The penta retentions in the second half inch, principally heartwood, are indicative of good, heavy, deep penetration and not just surface loading. A phenomena noted was the tendency of the oil to creep up the poles above the bands of emulsion application. The best average results in the first half inch were obtained with Woodtreat where the back-filling was delayed. The retention was 0.920 pound of penta per cubic foot. Next was the immediate back-filling with a retention of 0.753 pound, and the poorest was the wrapped stubs with a 0.598 pound retention.

The second half-inch reading for wrapped stubs showed up slightly better than the delayed back-fill, but the immediate back-filling was best of all. With a greater number of applications and borings, the three methods would probably average out more closely and the differences do not appear to be significant enough to justify the extra expense of wrapping cedar poles after the coating application or delaying the back-filling operation.

The consistently lower retention results below ground may indicate that some of the oil and penta is dissipated into the soil, but more probably that the wetter wood is more resistive to treatment and the penetration is slower. Another factor noted at the time the borings were taken below ground was that the Woodtreat at that level had not completely penetrated the wood or soil and probably a much greater retention would have been effected if the borings had been taken later. However, the consistently higher results above the ground line indicate that the coating is not too susceptible to rain wash-off or volatilization. By comparison, the penta retention results obtained by the Woodtreat application are four to seven times as great as for the penta-petroleum solution application at the first half inch, and four to five times as great at the second half inch.

Ground Line Test Treating Results—Creosoted Southern Yellow Pine: The sampling of these pole stubs was carried out the same as for the Western red cedar. No attempt was made to analyze these pole stubs for their creosote content and the

Table 1.—POUNDS OF PENTA PER CUBIC FOOT OBTAINED WHEN WOODTREAT AND B WOOD PRESERVATIVE WERE APPLIED AT THE GROUND LINE TO UNTREATED WESTERN RED CEDAR POLE STUBS

Poles from which 6′ matched stubs were obtained	Level assayed by lime ignition	Method of Application and Material Used											
		Woodtreat: back filled immediately			Woodtreat: back filled after gel dissipated			Woodtreat: wrapped and back filled			B-Wood Preservative Solution (5%)		
		Ground	Below	Above	Ground	Below	Above	Ground	Below	Above	Ground	Below	Above
A	1st ½ inch	0.750	0.420	1.310	1.120	0.587	0.999	0.648	0.405	0.828	0.191	0.122	0.1[illegible]
	2nd ½ inch	0.223	0.167	0.228	0.115	0.187	0.075	0.105	0.115	0.060	0.010	0.008	0.0[illegible]
B	1st ½ inch	0.530	0.346	1.160	1.140	0.625	1.030	0.662	0.483	0.562	0.193	0.230	0.2[illegible]
	2nd ½ inch	0.035	0.025	0.025	0.060	0.020	0.038	0.070	0.038	0.070	0.013	0.005	0.0[illegible]
C	2nd ½ inch	0.045	0.032	0.055	0.052	0.005	0.048	0.063	0.025	0.075	0.013	0.027	0.0[illegible]
D	2nd ½ inch	0.030	0.015	0.035	0.063	0.022	0.058	0.075	0.033	0.040	0.020	0.022	0.0[illegible]
Average retention	2nd ½ inch	0.083	0.059	0.086	0.072	0.058	0.055	0.078	0.053	0.061	0.014	0.016	0.0[illegible]
Average retention ground below and above	2nd ½ inch	0.076 ± 0.024			0.062 ± 0.014			0.064 ± 0.008				0.015	
Average retention	1st ½ inch	0.640	0.383	1.235	1.130	0.606	1.025	0.655	0.444	0.695	0.192	0.176	0.2[illegible]
Average retention ground below and above	1st ½ inch	.753			.920			.598				.163	

Table 2.—POUNDS OF PENTA PER CUBIC FOOT OBTAINED WHEN WOODTREAT AND B WOOD PRESERVATIVE WERE APPLIED AT THE GROUND LINE TO CREOSOTED SOUTHERN YELLOW PINE POLE STUBS

Poles from which 6' matched stubs were obtained	Level assayed by lime ignition	Method of Application and Material Used											
		Woodtreat: back filled immediately			Woodtreat: back filled after gel dissipated			Woodtreat: wrapped and back filled			B-Wood Preservative Solution (5%)		
		Ground	Below	Above	Ground	Below	Above	Ground	Below	Above	Ground	Below	Above
E	1st ½ inch	1.100	0.725	1.030	1.270	0.645	1.100	1.095	0.625	0.890	0.212	0.052	0.312
	2nd ½ inch	0.152	0.084	0.100	0.404	0.152	0.340	0.316	0.408	0.204	0.048	0.004	0.040
F	2nd ½ inch	0.232	0.192	0.224	0.496	0.564	0.264	0.328	0.468	0.204	0.028	0.008	0.076
Average retention	2nd ½ inch	0.191	0.138	0.162	0.450	0.358	0.302	0.322	0.438	0.204	0.038	0.006	0.058
Average retention total ground below and above	2nd ½ inch	0.194 ± 0.032			0.370 ± 0.068			0.321 ± 0.005			0.034		

original preservative retention of creosote was unknown. Borings were made and analyzed prior to the Woodtreat applications to confirm the negative readings on the chlorides so that we could be sure there would be no interference later with the subsequent penta readings after the Woodtreat or the penta-petroleum solution applications. Table 2 shows the results obtained by analyses of these borings.

The stubs were not from the same pole length, nor were they in a series of stubs from the same pole, as in the case of the Western red cedar poles. However, an average of 0.37 pound of penta per cubic foot was obtained in the second half inch where the back-filling was delayed and 0.321 where the emulsion coating was wrapped. Those two average retentions of penta for the second half inch are both well above the minimum requirement of the current A. T. & T. specification for pressure treatment of Southern pine poles with pentachlorophenol. The result obtained with immediate back-filling was 0.194 pound of penta average for the second half inch, but it is rather probable that analysis from more treated stubs would give a higher average.

Again, as noted with cedar stubs, there was a considerable volume of the emulsion left in the holes below ground due to slower penetration of the wet wood. Undoubtedly higher readings on the below-ground portion of these poles would have been obtained at a later date. Although there was no color or dye additive in the Woodtreat used for these applications, within a few days it was noted that the emulsion coating was turning black on the outside of the poles and before it had a chance to penetrate the wood. This indicated some sort of transference between the remaining creosote in the pole stub and the penta-petroleum coating on the outside of the pole. This may or may not be significant but it would seem to demonstrate that the residual creosote and the penta-in-oil solution in the surface coating are compatible. Certainly the residual creosote is not resistive to the penetration or dissipation of the penta-petroleum solution within the pole. Creepage was also observed on the creosoted pole stubs above the band of the Woodtreat coating.

Again, the results obtained by the Woodtreat applications were much superior to the retentions of penta obtained by the application of the penta-petroleum solution. In the second half inch, the retentions were 6 to 11 times as great and for the first half inch about 6 times as great as for the solutions.

Treatment of Existing Structures

In order to determine the effectiveness of Woodtreat in penetrating dry lumber or that which would represent the conditions in existing structures encountered, for example, by the pest control operator, the following laboratory tests were conducted to: show the relative penetration properties of various thicknesses of Woodtreat vs. some of the superficial methods of application, and to obtain a relative value of this type application in terms of equivalent brush coats. These tests and the results therefrom were not intended to represent an average treatment, but were carried out solely for comparative purposes.

Procedure: Matched 2-inch × 8-inch × 2-foot flat-grain, clear Southern yellow pine, Douglas-fir and red oak sections of average density were utilized to measure end, tangential, and radial penetration. The moisture content of the wood ranged from 10% to 14%. Where end penetration was to be observed, the flat- and edge-grain surfaces were sealed with three coats of a water dispersion of polyvinyl acetate. Where side penetrations were studied, the end grain was sealed in a similar manner. The solution used for the brush treatments was 5% pentachlorophenol in a range oil or kerosene carrier typical of solutions used in the pest control field.

End Penetration: Two brush coats of the 5% penta-petroleum solution were applied to the end grain of one end of a test specimen, ten brush coats to the other end. Brush coats were applied at the rate of two each day at eight-hour intervals. The subsequent matched pieces were treated with 20 brush coats; by a three-minute dip; and by an application of 1/16-, ⅛-, ¼-, and ½-inch thickness of Woodtreat, respectively.

Radial and Tangential Penetration: To the individual matched sections, 2, 10, and 20 brush coats of the penta solution were applied for comparison against a section treated by a three-minute dip and those treated with applications of Woodtreat 1/16, ⅛, and ¼-inch in thickness. In order that the thicknesses of Woodtreat would be as near uniform as possible, the calculated volume was applied on a weight basis and spread as evenly as possible with a trowel. The brush coats were flooded on liberally. Thirty days after application, the specimens were sectioned and analyzed.

Quantitative Analysis: Using the lime ignition method to determine chlorides calculated as penta, the second, fourth, and sixth inches of end penetration were analyzed. The first ⅛, second ⅛, and third ⅛ inch from four different borings made up a composite sample or one sample from each of the three levels on the flat grain surface. The same procedure was carried out on the edge-grain surface, making a total of six assays from each two-foot section. Prior to zoning for analysis the treated sections were scraped and brushed to avoid contamination from any surface crystallization or the water phase residue which might have contained some trapped penta.

Results: Tables 3 and 4 show the retained pounds of penta per cubic foot at the various levels. The retention pattern is as would be predicted for these three species of wood, with pine showing the heaviest loading followed by oak and fir in that order. The analytical work revealed that a half-inch thick end-grain application of Woodtreat to all species studied was 5 to 10 times as effective as the best of the superficial methods, which in this case was 20 brush coats. With

the exception of pine, the 1/16, 1/8, and 1/4 inch treatments followed a comparable pattern. For one reason or another, the pine at the 1/16 and 1/8 inch levels failed to measure up to the 10 and 20 brush coats. Conservatively speaking, it could be concluded that one Woodtreat end-grain application of 1/4 inch in thickness would be far superior to 20 brush coats of a 5% penta solution.

Analysis to determine flat- and edge-grain penetration of penta revealed that as little as a 1/16-inch thick coating of Woodtreat was superior to 20 brush coats of the penta solution on pine, fir, and oak specimens at the three 1/8-inch levels.

Although the preceding work was conducted with continuous film applications of the bodied emulsion, it has been subsequently demonstrated that mechanical applicators (Fig. 6), which apply approximately 2-inch bands to joists at intervals of 8 to 12 inches, afford a more effective means of controlling application rate and also eliminate waste of material. The equipment shown in Fig. 6 was obtained from the Alemite Company of St. Louis. We have tested equipment ranging in price from $35 to $1,000 and find much of their applicable equipment can be used for applying Woodtreat. With controllable flow and assorted sizes of nozzles, bands of variable widths and thicknesses can be obtained.

Summary

A new method or technique now exists for the treatment of wood in place. Employing the principle of emulsions, a chemically unmodified penta-petroleum solution is dispersed in a minor amount of water containing emulsion stabilizers. The resultant viscous emulsion is of a consistency that it may be troweled to a thickness of as much as one inch onto wood surfaces. Such a coating, through the evaporation of the water phase, breaks down at a rate in keeping with the absorption of the preservative solution by the wood, thus acting as a reservoir for the treating solution.

A protective coating at the external surface of the emulsion is formed by the residual components of the water-phase, ultimately minimizing evaporation of the carrier and displacement of the emulsion by rain and/or other agents. Field and laboratory tests corroborated by actual commercial applications have demonstrated the effectiveness of Woodtreat in affording deep, uniform penetration of poles by penta when applied at the ground line of poles in place. Time-consuming wrapping of the treatment is unnecessary and ease of application is an important consideration.

Structural fir and pine 2- by 8-inch, representative of that material encountered in the pest control field by the applicators of decay and termite control chemicals, when subjected to comparative laboratory treatments, has shown that a thin single coat of Woodtreat offers deep penetration of the penta superior to that which would be obtained with as many as 20 brush coats of a light 5% penta-petroleum solution. Application of Woodtreat is not limited to brush or trowel; mechanical equipment is also available which allows the even distribution of this penetrating composition.

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Table 3.—POUNDS OF PENTA PER CUBIC FOOT OBTAINED IN END GRAIN PENETRATION STUDIES

Application	Sample Depth Inches	Pounds of Penta per Cubic Foot S. Yellow Pine	Douglas-fir	Red Oak
3 Min. Dip.*	2"	0.000	.000	.000
	4"	0.00	.000	.000
	6"	0.00	.000	.000
2 Brush Coats*	2	.080	.000	.000
	4		.000	.000
	6		.000	.000
10 Brush Coats*	2	.080	0.10	.004
	4	.070	.000	.000
	6	.004	.000	.000
20 Brush Coats*	2	.160	.010	.029
	4	.050	.000	.008
	6	.030	.000	.000
1/16" thickness Woodtreat	2	.040	.020	.021
	4	.000	.000	.008
	6	.000	.000	.008
1/8" thickness Woodtreat	2	.128	.024	.020
	4	.000	.000	.000
	6	.000	.000	.000
1/4" thickness Woodtreat	2	.296	.080	.048
	4	.152	.009	.000
	7	.016	.000	.000
1/2" thickness Woodtreat	2	.404	.072	.143
	4	.340	.012	.050
	6	.216	.013	.036

*These applications with a standard penta wood preservative 5% penta in range or kerosene oil type solvent.

Table 4.—POUNDS OF PENTA PER CUBIC FOOT OBTAINED IN EDGE AND FLAT GRAIN PENETRATION STUDIES

Application	Sample Depth Inches	Pounds of Penta per Cubic Foot So. Pine	Doug.-fir	Red Oak
3 Min. Dip*				
Edge Grain	1st 1/8"	0.112	0.050	
	2nd 1/8"	.024	.006	
	3rd 1/8"		.000	
Flat Grain	1st 1/8"	.212	.020	.040
	2nd 1/8"	.100	.000	.000
	3rd 1/8"	.056	.000	.000
2 Brush Coats*				
Edge Grain	1st 1/8"	.100	.048	
	2nd 1/8"	.008	.000	
	3rd 1/8"	.004	.000	
Flat Grain	1st 1/8"	.092	.030	.030
	2nd 1/8"	.020	.000	.000
	3rd 1/8"	.004	.000	.000
10 Brush Coats*				
Edge Grain	1st 1/8"	.096	.090	
	2nd 1/8"	.068	.021	
	3rd 1/8"	.024	.000	
Flat Grain	1st 1/8"	.220	.090	.165
	2nd 1/8"	.060	.078	.050
	3rd 1/8"	.048	.006	.017
20 Brush Coats*				
Edge Grain	1st 1/8"	.342	.162	
	2nd 1/8"	.260	.021	
	3rd 1/8"	.048	.009	
Flat Grain	1st 1/8"	.492	.198	.165
	2nd 1/8"	.284	.051	.025
	3rd 1/8"	.092	.015	.020
1/16" Thickness Woodtreat				
Edge Grain	1st 1/8"	.632	.219	
	2nd 1/8"	.364	.021	
	3rd 1/8"	.196	.021	
Flat Grain	1st 1/8"	.504	.327	.215
	2nd 1/8"	.348	.066	.060
	3rd 1/8"	.320	.036	.030
1/4" Thickness Woodtreat				
Edge Grain	1st 1/8"	.744	.219	
	2nd 1/8"	.352	.024	
	3rd 1/8"	.342	.009	
Flat Edge	1st 1/8"	.896	.249	.630
	2nd 1/8"	.460	.111	.215
	3rd 1/8"	.316	.057	.060
1/4" Thickness Woodtreat				
Edge Grain	1st 1/8"	.744	.598	
	2nd 1/8"	.352	.048	
	3rd 1/8"	.288	.036	
Flat Grain	1st 1/8"	1.232	.363	.900
	2nd 1/8"	.860	.117	.110
	3rd 1/8"	.600	.102	.110

*These applications with a standard penta wood preservative 5% penta in range or kerosene oil type solvent.

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Discussion

John Reno (Pacific Lumber Co.): Has this new method been tested with the inclusion of water repellents and, if so, is it effective when applied to the ends of green wood which is then air dried or kiln dried?

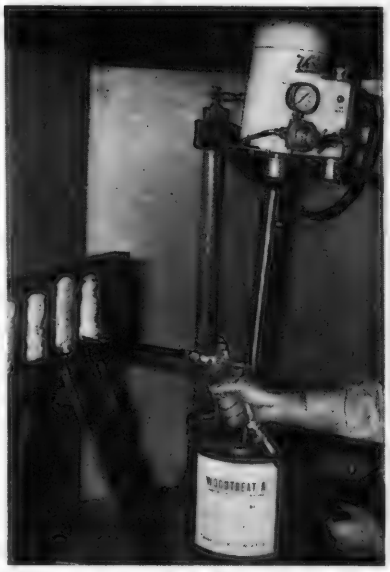

Fig. 6.—Mechanical application of Woodtreat.

Mr. Van Allen: Various water repellent combinations have been worked with to a minor degree with interesting results, however no extensive program has been undertaken yet. The emulsion form that we are employing here would not improve physically any wax or sealer as it functions only as a means of application.

C. S. Walters (University of Illinois): You mentioned that it is not necessary to wrap and back-fill, but Table 2 shows best results here.

Mr. Van Allen: Table 2 covers the creosoted yellow pine which were not matched; hence we were not justified in drawing such conclusions as in the case of the matched Western Red Cedar stubs.

George Fahlstrom (Osmose Wood Preserving Co.): I call attention to the fact that these test pole stubs were aerial sections and dry, not true ground line sections. Have you field data on actual inline poles.

Mr. Van Allen: The test sections were placed in the ground a considerable length of time before treatment. Subsequent rainfall in excess of one inch as recorded in this paper, resulted in conditions which could be described as anything except favorable. Where the mud was removed from around the poles, the below-ground area appeared saturated. Admittedly, this might not be the same thing as a pole in place for years. However, we have treated green southern yellow pine with exceptionally good results, although the length of time for penetration to occur is of course increased.

The Oscillating Pressure Method of Wood Impregnation[1]

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and

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A method for preservative impregnation of woods resistant to treatment by the usual pressure processes is described. The process utilizes rapid cycling of pressure and vacuum to obtain penetration of preservative salts in aqueous solution into unseasoned wood. Pressure is oscillated between 115 psi and 28 inches vacuum, with the period between cycles gradually lengthened. Underlying physical principles involved in treatment of wood by this process are discussed.

THE IDEA OF IMPROVING the penetrability of wood to liquids by the use of fluctuating pressure has been a subject of much speculation by wood technologists. Proposals for use of fluctuating pressure have ranged from simple two-cycle operations to the use of pulsations of pressure at ultrasonic frequencies. The only method of application of pulsating pressure that has gained any commercial importance so far is the double-Rueping process which is used in Europe for treatment of beech crossties (1) and to a limited extent in this country for treatment of oak crossties (2).

In seeking an explanation as to why some species of wood are easily penetrated while others can only be penetrated with difficulty, if at all, wood anatomists (3) (4) have pointed out that the numerous microscopic "port-hole" like structures called pits which line the walls of wood cells can act like check valves to impede liquid flow. In some species, the port holes are all closed by circumstances peculiar to the growth of the wood or to a closing action which takes place in drying.

[1] Presented at Session III, Wood Preservation, Forty-Tenth National Meeting, June 4–7, 1956, Asheville, N. C.

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S. T. Henriksson is a graduate chemical engineer from Royal Institute of Technology, Stockholm, Sweden. He is currently Head of Chemical Research Laboratory, Boliden Mining Co.

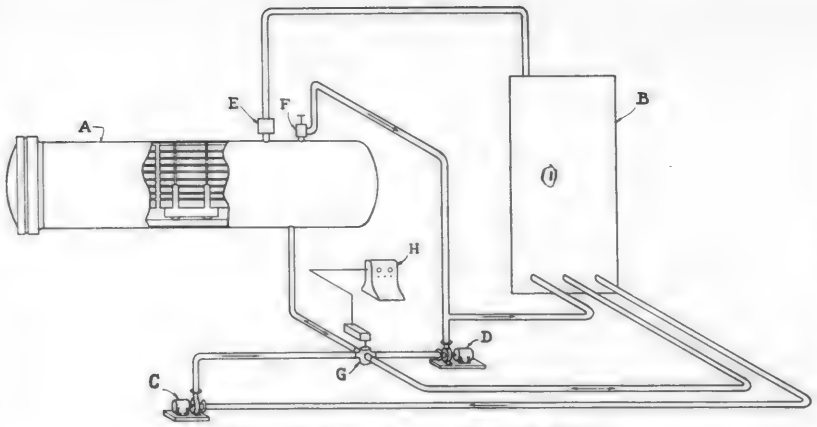

Fig. 1.—Oscillating pressure method plant.

Such species are relatively impenetrable. In others the check valves are closed by the force of the flow of liquid against the swinging gates as it is injected into the wood so that liquid flow is reduced as the time of flow is lengthened. When the check valves are closed, the wood is said to have aspirated tori.

This "aspirated torus" explanation of impenetrability (the torus being the structure in the wood cell wall corresponding to the porthole cover and "aspirated" meaning that is is closed) is an ingenious one which is supported by the results of many studies of fluid flow in wood (5(6)(7). These studies have shown that when a liquid is forced through a section of wood at a given pressure, the amount passing through in a given time interval decreases the longer the flow continues. However, after the liquid has passed in one direction for a long time and the flow has decreased substantially, if the direction of flow is reversed, the rate of flow will rapidly increase until it is as high as it was at the start of flow in the original direction. As flow continues in the new direction, it will decrease as before. The increase in flow fits in with the check valve idea since reversal of flow would open the closed swinging gates. The subsequent decrease in flow is explained by the fact that the gates come to rest against other seats positioned on the opposite side of the cell wall. The structure of the bordered pits of the cell wall between which the torus is positioned meets all of the requirements for such a double-acting check valve. In spite of the patness of this explanation, many observations indicate that it may not be the true one or at least that there are other unknown factors which also exert as important an influence on penetability of wood. Three examples of such observations are:

1. The number of aspirated tori found in an easily penetrated section of coast Douglas-fir was reported to average 92% while a specimen that was much more difficult to penetrate had an average of 99% of the tori aspirated(8). This small difference could hardly be credited with having caused the large difference in permeability observed.

2. Recent studies of the structure of bordered pits with the electron microscope show in many cases numerous wart-like protuberances scattered over the pit walls (9). Remember that the pit walls are supposed to serve as valve seats for the tori. The wart-like protuberances should give leaky check valves, yet they occur in species that are difficult to penetrate as well as those that are easy to penetrate.

3. The phenomenon of decreasing rate of flow with time has been observed with membranes of materials like collodion, gold beaters skin, parchment paper, and porcelain(10)(11). None of these have structures in them that could be said to correspond to the tori in the bordered pits of wood cells.

Regardless of the explanation as to why, the efficacy of reversal of the direction of flow in re-establishing the original high rate of flow in permeable woods is a well established fact, which has tended to strengthen the widespread belief that the use of fluctuating pressures would improve penetration in woods that are difficult to treat by ordinary means. While the double-Rueping process uses only one repetition of pressure and vacuum, it was proposed as early as the beginning of this century by Boucherie(13) and later on by Polysu(12) to use repeated cycles of pressure and vacuum to obtain penetration in refractory species. Development of the idea to the point of commercial application was accomplished through the work of Henriksson in the experimental plant of the Boliden Mining Co. in Skelleftehamn, Sweden in 1946(5).

Apparatus and Operation

Equipment for impregnating wood by the oscillating pressure method is shown in Fig. 1. The impregnating cyclinder A is the usual type found in wood preserving plants. The wood to be treated is placed in the cylinder which is then filled with treating solution pumped in from tank B by means of pump C. When the cylinder is filled with liquid, float valve E closes, and the cylinder pressure rises to about 115 psi when pressure regulating valve F opens to allow liquid to flow back to tank B. Pump D is started and an automatic timing device H activates the 4-way solenoid valve G. After a predetermined time interval, usually ½ to 1 minute after the cylinder pressure has reached 115 psi, the position of the ports of the 4-way valve changes and the liquid flow is reversed so that it is moving from the cylinder through pump D back to the storage tank. This quickly produces a vacuum of 26 to 28 inches of mercury in the cylinder.

The float valve is a ball type having seats top and bottom so that when the liquid is pumped from the cylinder it closes on the lower seat which prevents entry of air and allows establishment of vacuum in the cylinder. It should be noted that it is not necessary to empty the cylinder to establish this vacuum. Only a relatively small amount of liquid is pumped out. After a period of ½ minute to 1 minute of vacuum, the position of the 4-way valve is again changed so that liquid is pumped back into the cylinder. Any air that was withdrawn from the wood by the preceding vacuum cycle is eliminated from the cylinder through the float valve before the pressure of 115 psi. is re-established.

The reason that pumps C and D have individual circuits to the storage tank is to prevent excessive mechanical heating of the liquid in the pipelines that would occur if the same liquid is re-cycled for long periods. In small experimental units, it has been found satisfactory to use a single pump, reversing its direction to produce the changes in pressure.

The device used for activating the 4-way valve can be a cam pattern set on a suitable instrument. The type of control used by the Boliden Co. in its plant as Skelleftehamn is one which is operated by a strip of photographic film on which are bands of black exposed emulsion alternating with bands of clear film. This is passed between a photocell and a source of light connected with a relay circuit which changes the position of the 4-way valve. Spacing of the dark and light bands on the film is based on theoreti-

Table 1.—COMPARISON OF RESULTS OBTAINED IN TREATMENT OF SPRUCE AND PINE BY THE OSCILLATING PRESSURE METHOD AND THE CONVENTIONAL FULL CELL METHOD

Tree No. (1)	Post (2)	Diameter Inches (3)	Method of Treatment (4)	Solution Retention* in Sapwood Lbs./Cu. Ft. (5)	Sapwood Depth Inches (6)	Preservative found by Analysis of Sapwood Arsenic Found Calculated to Per cent As_2O_5			Calculated Moisture Content§	
						Outer 1/3 (7)	Second 1/3 (8)	Remainder of Sapwood (9)	Initial % (10)	Final % (11)
					A. SPRUCE					
1	A	7.5	OPM†	16.2	1.1	1.07	0.84	0.64	69	95
1	C	5.7	OPM	18.0	1.1	1.15	0.80	0.54	80	108
2	B	6.6	OPM	16.6	1.1	1.21	0.89	0.43	64	93
2	D	5.0	OPM	16.7	1.1	1.22	0.94	0.58	89	120
Average		6.2		16.8	1.1	1.16	0.87	0.55	76	104
1	B	6.5	FC‡	13.5	1.1	0.39	0.02	Trace	79	151
1	D	4.5	FC	13.0	1.1	0.38	Trace	Trace	106	139
2	A	7.2	FC	19.3	1.1	0.21	Trace	Trace	72	106
2	C	5.9	FC	14.4	1.1	0.26	Trace	0.01	74	107
Average		6.0		15.1	1.1	0.31	Trace	Trace	83	126
					B. SCOTCH PINE					
1	B	7.3	OPM	25.6	1.4	1.12	0.63	0.35	20	80
2	A	8.7	OPM	15.9	1.4	1.27	0.87	0.20	43	76
3	B	7.4	OPM	19.9	1.7	1.12	0.56	0.46	32	83
4	B	7.9	OPM	30.6	2.8	1.70	0.97	0.63	15	95
Average		7.8		23.0	1.8	1.30	0.76	0.41	28	84
1	A	7.6	FC	14.2	1.4	0.28	0.11	0.03	57	88
2	B	7.9	FC	19.9	1.4	0.39	0.14	0.13	42	83
3	A	7.8	FC	8.6	1.7	0.24	0.07	0.13	74	94
4	A	8.8	FC	20.3	2.8	0.84	0.36	0.22	21	81
Average		8.0		15.8	1.8	0.44	0.17	0.13	49	87

*Solution retention does not reflect exchange of treating solution for water in wood that occurs in OPM.
†OPM = Oscillating pressure method—18 hr. treatment in which pressure fluctuated between 115 psi and 28 inches of mercury for several hundred cycles.
‡FC = Full cell process—1 hr. preliminary vacuum plus 17 hrs. pressure at 115 psi.
§Moisture content calculated from initial and final weight per cubic foot; 26.8 lbs./cu. ft. used for spruce; 30.4 lbs./cu. ft. for pine.

cal considerations involving the depth of wood to be penetrated, magnitude of pressure to be used above atmospheric and depth of vacuum, as well as practical experience obtained in processing various kinds of wood by this method.

At the start of the treatment, a complete cycle from pressure above atmospheric to vacuum and back to pressure above atmospheric requires about 1 minute. During this minute, the pressure is higher than atmospheric about 30% of the time and below atmospheric the remaining 70%. As the cycles are repeated, they are gradually lengthened until at the end of the run the duration is about 6.5 minutes. Also, the proportion of the time when the pressure is above atmospheric is gradually increased with repetition of cycles so that at the end the pressure is above atmospheric about 85% of the time (approx. 5½ minutes) and below atmospheric the remaining 15% (approx. 1 minute).

Green wood of large cross-section that is difficult to treat requires about 20 hours for impregnation during which about 400 cycles of pressure and vacuum are used. With dry wood of small cross-section that is easy to treat, a total impregnation time of about 2 hours is used with the pressure-vacuum cycles repeated about 40 times.

Wood to be impregnated by the process can be either green, partially seasoned, or dry, but it is in the treatment of green wood that the greatest improvement is obtained with the oscillating pressure method as compared with the usual methods of impregnation.

Preservatives Used

Preservatives used with the process are usually aqueous solutions of inorganic salts. Liquid organic compounds or organic solids dissolved in suitable solvents may also be used for treatment of wood by this method.

In Sweden the impregnating solutions employed have been principally two improved modifications of Boliden salt known as S–25 and K–33. The compositions of these salts is as follows:

		S-25	K-33
Arsenic pentoxide	As_2O_5	36.0%	34.0%
Chromic acid	CrO_3	23.5%	26.6%
Zinc oxide	ZnO	11.5%	0
Copper oxide	CuO	3.8%	14.8%
Water of constitution	H_2O	25.2%	24.6%
		100%	100%

These salts undergo chemical reactions in the wood which may be expressed thus:

$$1.4\ CrO_3 + 0.9\ MeO + As_2O_5 = 1.4\ CrAsO_4 + 0.3\ Me_3(AsO_4)_2$$

Me indicates the metal ions copper or zinc.

The compounds chromium arsenate and copper and zinc arsenate formed as products of the reaction are insoluble and are deposited in the wood where they function as highly efficient, virtually non-leachable preservative agents. It will be noted that this reaction produces no inactive products which remain in the wood, as does the original Boliden salt which forms sodium sulfate. Sodium sulfate from the preservative standpoint is inactive. Sodium sulfate in the wood also lowers the electrical resistance which is undesirable in poles carrying electric circuits. The improvements gained by S–25 and K–33 over the original Boliden salt are, lower leachability, lower corrosiveness, and higher electrical resistance.

Treating solutions for use with the oscillating pressure method are prepared by dissolving S–25 or K–33 in water to produce a solution of about 2% total salt. The solutions are used at temperatures below 120° F. to prevent premature formation of the insoluble arsenates which at higher temperatures will precipitate as sludge. Formation of sludge results not only in loss of chemical but also results in poor penetration of the wood caused by blocking of the paths of flow of liquid into the wood.

Experimental Tests

Table 1 shows the results of a series of tests in which the oscillating pressure method was used to impregnate green round posts of spruce *(Picea excelsa)* and scotch pine *(Pinus silvestris)*. Also shown in the table are the results obtained on mated posts cut from the same trees and processed by the full-cell method.

The trees from which the posts were cut were delivered to the treating plant with the bark on to keep them moist. Just before impregnation, the bark was removed.

The two spruce trees used were cut into four posts each. These posts were about 6 inches in diameter and 94.5 inches long. One set of the posts was impregnated by the oscillating pres-

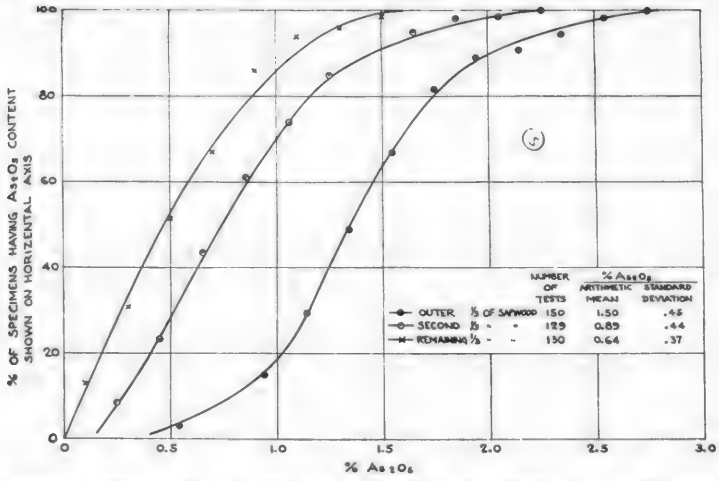
% OF SPECIMENS HAVING As2O5 CONTENT SHOWN ON HORIZONTAL AXIS
% As2O5
NUMBER OF TESTS
% As2O5 ARITHMETIC MEAN
STANDARD DEVIATION
OUTER 1/3 OF SAPWOOD 150 1.50 .46
SECOND 1/3 " " 129 0.89 .44
REMAINING 1/3 " " 150 0.64 .37

Fig. 2.—Distribution of As_2O_5 in sapwood of timbers from commercial charges treated by the oscillating pressure method.

sure method (OPM) and the other by the full-cell (FC) method.

The four pine trees were cut into two posts each and one set of four posts was impregnated by the OPM and the other by FC. These posts were about 8 inches diameter and 48.5 inches long.

The posts were impregnated with a solution containing approximately 1.4% S–25 preservative.

Impregnation by OPM was carried out for 18 hours, during which the pressure in the treating cylinder fluctuated between 115 psi and 28 inches of mercury vacuum for several hundred cycles. The duration of a cycle of fluctuation (starting at 115 psi pressure, going to 28 inches vacuum, then returning to 115 psi) is about 1 minute when the treatment begins. At the end of the run, the fluctuation cycle is about 6 minutes.

Full-cell impregnation was begun with 1 hour vacuum. The cylinder was then filled with solution and the pressure raised to 115 psi, which was maintained for 17 hours.

Comparison of the averages, shown in Table 1, for the four spruce posts treated by OPM with those treated by the FC process shows the following:

There was little difference in the gain in weight due to absorption of solution by the wood treated by the two methods. The average by OPM was 16.8 lbs/cu.ft.; by FC 15.1 lbs/cu.ft. (see column 5 of Table 1).

With a concentration of 1.4% of salt in the solution, multiplication of the above values for solution retained by 0.014 would indicate that the solid preservative retained by OPM was 0.24 lbs/cu.ft., and by FC 0.21 lbs/cu.ft. However, as is indicated by the first footnote (*) to the table, there is an exchange of treating solution for water in the wood when OPM is used so that gain in weight of the posts can not be used as a true indication of retention.

More exact values for retention of preservative are shown in columns 7–9 of Table 1. The retention is given in terms of per cent As_2O_5 found by analyzing the sapwood portion of discs cut from the posts after treatment. Since analytical tests indicate that the various constituents are absorbed by the wood in the proportions that they are present in the solution, a close approximation of the total salt can be obtained from the As_2O_5 figures by dividing them by 0.36 because S–25 contains 36% As_2O_5.

By this means, the total salt retained by the four spruce posts was

$$\frac{(1.16 + 0.87 + 0.55)}{3} \div 0.36 =$$

2.4%, and this times the weight per cubic foot of spruce, 26.8 pounds, gives a retention of 0.64 lbs/cu. ft. of S-25. This is about 2½ times as much as is indicated by the retention of solution shown in column 5, and the concentration of 1.4%. This method of calculation applied to the As_2O_5 found by analysis of the FC posts gives a retention value only about half that indicated by the solution retention. End penetration of solution probably accounts for this discrepancy.

The exchange of treating solution for water in the wood makes it necessary to add additional salt to the solution between charges when green charges are being treated by the oscillating pressure method.

Columns 7–9 of Table 1 show far better penetration in the spruce treated by OPM than in FC as is indicated by the amount of As_2O_5 found in the three zones of the sapwood. This is true also in the case of the pine, but the difference is less striking because the pine had undergone sufficient drying before it was treated so that better penetration was obtained by the FC method than would have been the case had it been thoroughly green.

Table 2 shows comparative results obtained in scotch pine at varying stages of seasoning when impregnated with K-33 by the two methods. As a guide for judging the satisfactoriness of treatment, it has been recommended that the three zones of the sapwood should contain minimum amounts of As_2O_5 as follows:

Outer ⅓ of sapwood	1.0%
Next ⅓ of sapwood	0.5%
Remaining ⅓ of sapwood	0.2%

Table 2.—COMPARISON OF RESULTS OBTAINED BY THE OSCILLATING PRESSURE AND FULL CELL METHODS IN TREATMENT OF SCOTCH PINE AT VARIOUS STAGES OF SEASONING

Number of Specimens Tested (1)	Type of Timber (2)	Seasoning (3)	Impregnating Time Hours (4)	Treating Process (5)	Depth of Sapwood Inches (6)	Solution Retention lbs./cu. ft. (7)	Preservative Found by Analysis of Sapwood Arsenic Calculated as As_2O_5		
							Outer ⅓ (8)	Second ⅓ (9)	Remainder of Sapwood (10)
12	Round	Dry	2	OPM*	1.3	25.9	0.97	0.68	0.48
12	Round	Dry	2	FC†	1.4	33.4	0.93	0.70	0.59
13	Round	Dry	4	OPM	1.7	19.6	1.39	0.90	0.65
13	Round	Dry	4	FC	1.7	25.6	1.26	0.96	0.84
13	Round	Partly seasoned	4	OPM	1.6	17.6	0.94	0.71	0.45
13	Round	Partly seasoned	4	FC	1.6	22.0	0.79	0.45	0.35
16	Round	Partly seasoned	8	OPM	2.2	10.3	0.87	0.51	0.36
16	Round	Partly seasoned	8	FC	2.2	12.2	0.54	0.17	0.08
2	Cross-ties	Freshly-cut	4	OPM	2.0	19.4	0.74	0.40	0.26
2	Cross-ties	Freshly-cut	4	FC	2.3	14.8	0.39	0.07	Trace
6	Cross-ties	Freshly-cut	8	OPM	1.8	5.6	0.72	0.46	0.36
6	Cross-ties	Freshly-cut	8	FC	1.9	5.2	0.19	0.03	0.05
14	Cross-ties	Freshly-cut	14	OPM	1.9	15.8	1.36	0.92	0.71
14	Cross-ties	Freshly-cut	14	FC	1.9	15.6	0.64	0.31	0.21

*OPM = Oscillating Pressure Method.
†FC = Full Cell Method.

Table 2 shows that satisfactory treatment of dry wood was obtained by both the OPM and FC methods in 2 to 4 hours. Partially seasoned round wood required more than 8 hours by both methods, while 14 hours was required to treat green cross-ties by the OPM. Fourteen hours was insufficient for satisfactory treatment of green cross-ties by the FC method. These data also show that the greatest improvement of the OPM over the FC method is experienced when green wood is impregnated.

Commercial Treatments

The accompanying photographs (Figs. 3, 4, 5) show views of the commercial scale OPM treating plant at Skelleftehamn which has been in operation since 1951. Approximately 2½ million board feet of spruce and pine have been processed by OPM in this plant. The treating schedules used are as follows:

	Time hours	Number of oscillating pressure cycles
Green wood, large cross-section	22	406
Green wood, small cross-section	14	281
Partially dry wood	8	161
Dry wood, large cross-section	4	81
Dry wood, small cross-section	2	41

Fig. 2 shows the distribution of As_2O_5 in the sapwood of OPM impregnated timbers which were sampled at the commercial plant during 1955. The samples were taken from sawn lumber, posts, poles, and cross-ties. The sapwood from each sample was divided into three zones, the outer 1/3, the second 1/3, and the remaining 1/3. These zones were analyzed for arsenic by means of a spectrograph and the results reported as As_2O_5. A frequency analysis revealed a slight negative skew in the data as indicated by the fact that the 50 percentile values of the curves of Fig. 2 are about 0.14 of a percentage point below the arithmetic means shown in tabular form on Fig. 2. For example, the arithmetic mean for the outer zone is 1.50% As_2O_5 while the 50% point on the curve for the outer zone shown on Fig. 2 is 1.36%.

Based on the statement made above that satisfactory treatment requires at least 1% As_2O_5 in the outer zone, Fig. 2 shows that less than 20% of the specimens tested were non-conforming. The second zone shows 28% non-conforming on the basis of 0.5% minimum As_2O_5, while 22% of the inner zone values are non-conforming on the basis of a minimum of 0.2% for that zone. Of course, it is recognized that preservative retentions in wood have never been specified on such a rigorous basis, that is, requiring minima for more than one zone. These comparisons are given merely to show how closely the treating results approach the ideal that has been set up. No similar statistical data are available for conventional methods of treatment for comparisons.

Fig. 3.—Yard of OPM treating plant at Skellfeteham, Sweden. Roof of ore-dressing plant (background) is Boliden salt-treated lumber.

Cost of Treatment

The equipment for the oscillating pressure method costs only slightly more than that required for treatment of air seasoned wood by the full cell process. Since OPM impregnation can be carried out satisfactorily on green wood, comparison with conventional processes should be made on that basis. In this case the OPM plant equipment cost is much less than for a full cell plant equipped for treatment of green wood. The latter would require a boiler plant to supply heat for steaming or artificially drying the green wood as well as a vacuum and condenser system. The OPM plant re-

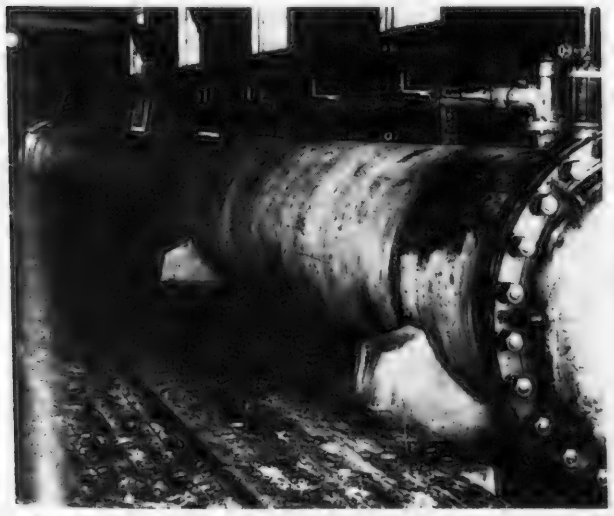

Fig. 4.—Commercial oscillating pressure treating cylinder with 805 cu. capacity. Ball float valve and pressure regulating valve are on top right.

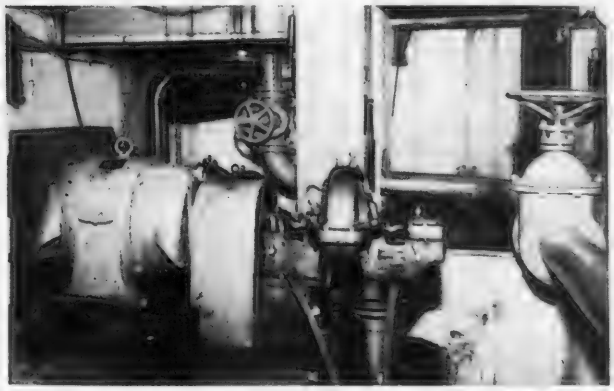

Fig. 5.—Pump room of commercial OPM plant. Pump in foreground is for above atmospheric pressures, with pump for vacuum cycles behind it. Process control instrument is partly hidden by motor of pump.

quires one extra liquid pump, a special ball check valve, and an automatic process control device for oscillating the pressure. These items for a cylinder 6 feet in diameter by 50 feet long would cost less than $5000.

Operating costs of the plant are low since green wood can be treated without preliminary conditioning. In treating green wood, the process does have the disadvantage of requiring long periods for impregnation, 14 to 22 hours. However, since the operation uses no heat and is simple enough to leave on automatic control, the cost would be less than that of steaming or other conditioning operations.

Just as in the full cell process, the cells of the wood are completely filled with liquid when it is impregnated by the oscillating pressure method. The cost of re-drying will therefore be about the same as for the full cell Method if the treated wood is to be dried before use.

The overall cost of treatment of green wood with S-25 or K-33 by the oscillating pressure method would be about $25 per thousand board feet in the U. S. This includes the cost of the chemical but not the cost of re-drying. The cost would be about the same for other water borne salts like chromated zinc chloride or Wolman salt if these are used for OPM treatments.

Experimental tests with the oscillating pressure method will be carried out in the U. S. this year. Since the process offers promise as a means of treating species that are normally resistant to treatment, a number of refractory western conifers like Engelmann spruce and Intermountain fir will be included in the tests as well as the refractory heartwoods of eastern white oak and red gum.

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Discussion

R. M. Lindgren (U. S. Forest Products Laboratory): Is there evidence that improved heartwood treatment is also obtained?

Mr. Hudson: Most of the experimental work reported was done on round wood so that the sapwood was on the outside. It treated well. There was some penetration in the underlying heartwood. Experimental work to be done in this country this year will be carried out on sawn specimens with heart faces as well as on round specimens.

N. C. Higgins (Michigan State University): Can wood treated in this manner be given a rougher drying treatment because of salts in wood? Would this be like chemical drying?

Mr. Hudson: No, this process is not one designed to improve drying. Chemical drying or chemical seasoning as it is generally called employs high concentrations of salt, urea, or sugars in the drying surface to lower the vapor pressure of water there so that excessive drying out does not take place to cause checking. The oscillating pressure method is a process designed to improve penetration, not drying.

Eldon Behr (Chapman Chemical Co.): Compared to diffusion into green wood, what relative difference is there between penetration by this method and by diffusion?

Mr. Hudson: Penetration by this method is much more rapid than would take place by simple diffusion. The rapid oscillations of pressure and vacuum tend to force the impregnating liquid into the wood, removing air from the cells and part of the sap which they contain.

Anon.: How can the cylinder be emptied in one minute?

Mr. Hudson: The cylinder is not emptied. Only a few gallons need be removed to create a vacuum.

Anon.: Has this same process been used on hardwood?

Mr. Hudson: No, tests are still to be made.

The Effect of Boring Speed and Feed Rate on the Strength of Glued Dowel Joints in Tension[1]

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The relationships of RPM and feed speed to the production of well machined holes for dowel joints have been studied for one tool and three species of wood. The role of tool heating in determining proper tool operating conditions is discussed. RPM had a greater influence on dowel joint strength than feed speed or chip thickness. The need of high speed steels for improved tool life is indicated.

Introduction

THE LITERATURE ON WOOD MACHINING contains few references to the wood boring process. Considerable interest in this machining process exists in those wood products industries where boring is an important production operation. Tool costs and hole quality are important factors in the profit picture for these manufacturers. Tool costs are directly related to wear and tool life, while hole wall quality may affect losses of work in process as well as final performance of the product in service.

The smoothness of the hole wall surface produced by a boring tool affects the strength of the glue bonds in joints using dowels or round tenons. It is also a quality factor to be considered in movable joints or bearings and the exposed features of some products.

Purpose of the Study

During the past few years, several aspects of the wood boring process have been under investigation. One of the dependent variables has been the quality of the hole walls. The actual effect of this surface condition on the strength of a dowel joint seemed worthy of study. Throughout the wood industry there are two schools of thought on the preparation of surfaces for gluing. One holds to the belief that a roughened surface enhances a mechanical bond while the other supports the contention that smoothly finished surfaces which permit thin glue lines lead to superior chemical adhesion. If the effect of surface condition should be found insignificant over any fairly wide range of chip thickness, the selection of appropriate boring speeds and feed rates for any application would have considerable latitude.

This investigation was undertaken to determine the effect of boring tool speed and chip thickness on the strength of glued dowel joints in tension. It encompasses both the effects of hole wall roughness and overheating.

Summary

Extensive tests were made to determine the effect of boring speed and feed speed on the strength of glued dowel joints. These two machine variables influence joint strength through their effects on hole wall surface roughness and overheating or charring of the wood.

The experimental work was performed on specimen holes bored at 1620, 2880, and 4430 rpm. Feed rates were controlled to produce chip thickness of 1/128, 1/64, 1/32, and 1/16 inches.

Species of wood tested were sugar maple, *Acer saccharum;* red oak, *Quercus borealis;* and northern white pine, *Pinus strobus.* All dowels were yellow birch, *Betula lutea,* having a nominal diameter of 3/8 inch. A polyvinyl acetate adhesive was used in making the dowel joints.

The results showed that hole wall surface quality is affected both by the thickness of the chips removed by the boring tool and its rotational speed. The effect of chip thickness on hole wall smoothness is an important factor contributing to the strength of dowel joints in northern white pine. This result is believed to represent a general condition for low density species of wood. This effect is less important in the boring of sugar maple. Sugar maple is a dense wood of relatively uniform structure and the effect of increased chip thickness on wall roughness is less pronounced than for lower density species or species having bands of low density springwood. The strength of dowel joints in sugar maple was not greatly reduced as the chip thickness was increased. Red oak, which has bands of porous springwood, showed somewhat lower dowel joint strength when holes were bored at feed speeds to produce large chip thicknesses. However, this effect was not great.

The above relationships between chip thickness and dowel joint strength were influenced, or masked, by the effect of boring speed. The strengths of dowel joints in holes bored at identical chip thicknesses, but at different spindle speeds, were not the same. Joint strength, for constant chip thickness, showed in general a reduced value at the highest boring speed, as compared to the 1620 and 2880 rpm speeds in the case of sugar maple. However, for the red oak and northern white pine specimens, joint strengths for holes bored at 1620 and 4430 rpm were reduced below the values obtained at 2880 rpm. This relationship showed highest joint strength at the intermediate speed, which was attributed to temperature effects due to the balance between heat generated in cutting and heat dissipation into the tool bit and the wood. A more detailed discussion appears under the heading "Factors Affecting Results".

Spindle speed has a greater influence on joint strength than does chip thickness.

No significant difference in the strength of joints made with spiral grooved and plain dowels was evident.

Some observations regarding im-

[1] Presented at Session IX, Wood Machining, FPRS Eighth National Meeting, June 4–7, 1956, in Asheville, N. C.

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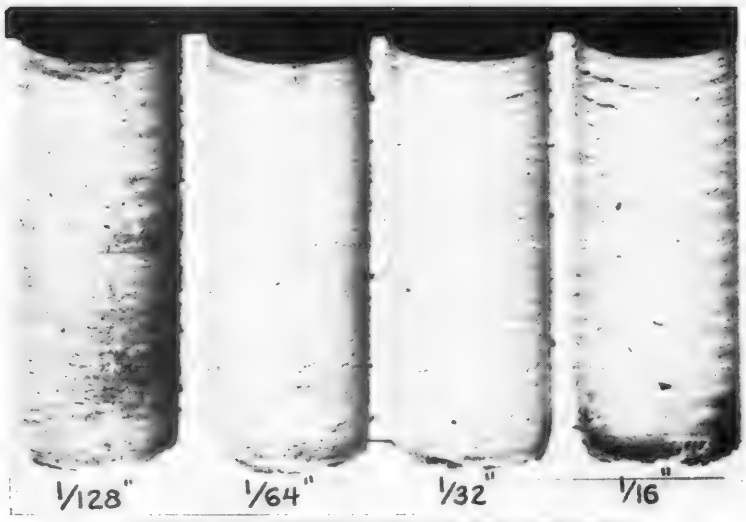

VARIOUS CHIP THICKNESSES USED IN BORING ¾-INCH HOLES
Fig. 1.—The effect of chip thickness on hole wall roughness.

proved tool design are included in this report.

General Considerations

Hole Wall Roughness: The physical condition of the hole wall surface is related to the feed rate of the tool. At any given tool rpm, the roughness of the wall surface increases as the feed rate is increased. The thickness of the chips or shavings cut by a boring tool at any given rpm is directly proportional to the rate of feed of the tool into the wood. The chip thickness can be computed using this formula:

$$t = F/Nn$$

where

t = chip thickness, inches
F = feed rate, inches per minute
N = tool rpm
n = number of cutting edges on the tool

The effect of chip thickness on wall roughness is illustrated in Fig. 1. The scribing marks on the hole wall are due to the action of the spurs. At large chip thicknesses, the spurs penetrate more deeply into uncut wood on each revolution of the tool than when chip thicknesses are small, as illustrated in Fig. 2.

Conventional spur bit designs do not provide a gullet space to accommodate the material severed by the spurs. The spurs do not remove a chip but merely scribe a furrow in the wood at the periphery of the tool, somewhat in advance of the main cutting edges. The wood fibers are severed to prevent the main cutting edges from tearing them from the hole wall surface. These severed fibers are bent and compressed inward toward the center of the tool and are subsequently cut away by the main cutting edges. This bending and compressing action imposes stresses on the spurs to deflect them outward. If the penetration of the spurs is great, as at high feed rates, this stress evidently deflects the spurs sufficiently to compress and deform fibers on the hole wall, leaving a rough surface condition.

Since the penetration of the spurs is directly related to the feed rate, it seems quite natural that the conditions depicted in Fig. 1 occur as they do. In fact the spurs may assume a permanent deflection after an extended period of operation at high feed rates, particularly when boring dense species of wood. Spurs which were damaged under such conditions are shown in Fig. 3.

Fig. 3.—The spurs on this boring bit were permanently bent by overheating and stressing in boring yellow birch at a 1/16-inch chip thickness.

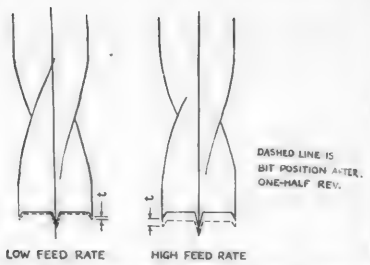

Fig. 2.—Penetration of spurs into wood at periphery of the hole.

Goodchild[2] reports that fibers may cling to the leadings edges of spurs. This would also cause rough hole walls. The cutting action of spurs exposes them to severe stress and frictional heating conditions which cause rapid wear and blunting.

The foregoing discussion has been limited to the consideration of different chip thicknesses resulting from feeding the tool into the wood at various rates—for a single speed of rotation. A specific chip thickness can be obtained at any speed of rotation if the ratio of feed rate to rpm is maintained. For example, a double spur bit will cut a 1/64-inch chip at 1200 rpm and 37.5 inches per minute feed rate, at 2400 rp mand 75 inches per minute, and at 3600 rpm and 112.5 inches per minute. However, the quality feature which is affected by the rpm used is overheating of the wood rather than surface roughness. This is reflected as a charring or scorching of the wall surface.

Overheating and Charring of the Wood: It is interesting to note that, at low rpm (600 rpm), the hole wall quality was dependent only on chip thickness as it affected roughness. Heating effects were unimportant. At low speed the heat generated by the cutting action was readily absorbed by the tool and dissipated into the chuck or the atmosphere. No great temperature rise in the wood was evident. However, at tool bit speeds high enough to develop substantial tool bit temperatures, the heating effect associated with the speed used becomes a matter for serious consideration. While we have not established a definite "danger-zone" temperature, it is believed that 300 to 400° F. defines its general location.

Charred or scorched hole surfaces present a poor appearance, which may be detrimental to product quality. More important is the fact that charred wood has little strength and scorched wood may have surfaces glazed by flowed lignin, either of which cause a weak link in a wood-glue bond.

[2] Goodchild, R. 1955. The machining of wood. Forest Products Research Bull. 35. Dept. of Scientific and Industrial Research. London.

CHIP SIZE 4400 RPM

Fig. 4.—Hole wall surfaces which have been overheated, scorched, and charred.

Wood which has been exposed to high temperature may be rendered non-polar[3] to such an extent that the bond at the wood-glue interface is unable to develop full strength, even though no visible evidence of charring is present.

Figure 4 illustrates a series of hole surfaces produced at conditions causing overheating and charring. Although overheating without charring cannot always be detected visually, it is detectable as low strength glued dowel joints, tested in tension.

Design of Experiment

The experimental design consisted of testing glued dowel joints in three species of wood, using one dowel size, two dowel types, one adhesive, and one boring tool. The independent variables were the boring conditions. Ten specimens were prepared for each species at each of the conditions described in Table 1. The dependent variable was strength of the glued dowel joint in tension. A total of 720 specimens were required.

Test Specimens

Test specimens representing three species of wood were used in the experiment. The dimensions are shown in Fig. 5. The test blocks were sugar maple (mean specific gravity[4] of 0.65), red oak (mean specific gravity of 0.70), and northern white pine (mean specific gravity of 0.33). All

[3] ...ular forces play an important role in wo... e bonds. The bond between polar mo... is stronger than that between polar and ...-polar molecules. Normal wood con-tains ... molecules, as do wood adhesives. If th... ood surfaces become non-polar, the effec... the molecular bonds is greatly re-duc... d the overall wood–glue bond is weak...

[4] Sp... gravities are based on weight and volu... hen oven dry.

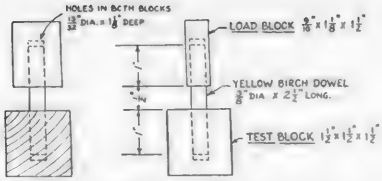

Fig. 5.—Dimensions of test specimens.

of the load blocks were sugar maple. Both plain and spiral grooved dowels were used. They were all made from yellow birch, with a nominal diameter of 3/8 inch, 2½ inches long, and with chamfered ends for a distance of approximately 1/8 inch from each end. All material used in the tests was conditioned to an equilibrium moisture content of 7 per cent.

Random samples of each dowel type showed a difference between major and minor diameters of 0.0036 inches for the plain dowels, and 0.002 inches for the spiral grooved dowels. The mean diameter of the plain type dowels was 0.384 inches. For the spiral grooved dowels this was 0.381 inches.

To provide a clearance between the holes and the dowels, a bit was ground to 0.391 inches. Thus the difference between hole size and dowel size was 0.007 inches for the plain dowels and 0.010 inches for the spiral grooved dowels. These clearances are about midway between 1/128 and 1/64 inches, or slightly less than the clearance reported by Nearn et al[5] for high strength joints using 3/8-inch diameter dowels.

The holes in the test blocks were bored perpendicular to the grain, without particular regard to the orientation of the annual rings.

Boring Tool

A double spur machine bit with a brad point (Greenlee Tool Co. No. 177 Spur Machine Drill) was used in this experiment. This 13/32-inch diameter bit was ground to a 23/64-inch (0.3906) diameter the full length of the shank. The helix and cutting angles were both 27 degrees.

The specimens were bored on a hydraulically fed drill press at controlled feed speeds. An electric stroke timer was used to check all feed speeds. The specimens were bored in continuous succession to permit the tool to come to an equilibrium operating temperature, simulating production boring.

[5] Nearn, W. T., Norton, N. A., and Murphey, W. K. 1953. The strength of dowel joints as affected by hole size and type of dowel. Jour. of FPRS III (4): 14–17, 72.

Table 1.—RPM—CHIP THICKNESS COMBINATIONS USED IN THE EXPERIMENT

RPM	1620	2880	4430
Chip thickness, inches	1/128	1/128	1/128
	1/64	1/64	1/64
	1/32	1/32	1/32
	1/16	1/16	1/16

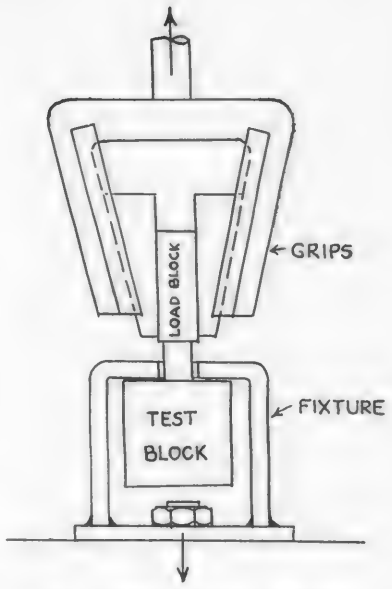

Fig. 6.—Method of load application.

Wood-Glue Bond

A polyvinyl acetate adhesive was used for these tests. It was applied to the holes and to the dowels with brushes. The dowels were inserted into the load blocks to a depth of one inch. After a four-day cure, these assemblies were inserted into the test blocks to a depth of one inch. An additional five days were allowed for curing the joints, after which the specimens were broken in tension.

Test Procedure

Tension testing was performed on a Riehle 5,000 lb. universal testing machine. The load blocks were held between the grips as shown in Fig. 6. The test grips were connected to the testing machine yoke through a universal joint. A slotted fixture, shown in Fig. 6, permitted alignment of the specimens in the vertical position as the load was applied. The rate of loading was 0.25 inches per minute. Breaking loads and per cent wood failure were recorded for each specimen.

Results and Discussion

The size of each sample group was ten specimens. In some instances failure occurred in the load blocks or in the dowel between the load blocks and test blocks. Since we were only interested in the performance of the glue joint in the test block, all such failures as occurred outside of the test block were eliminated in analyzing the results.

To accomplish this, the sample

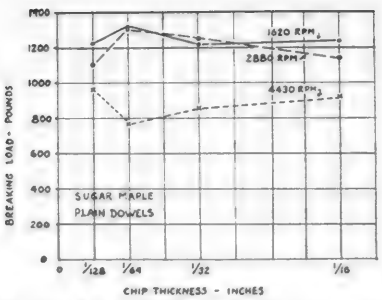

Fig. 7.—Breaking load vs. chip thickness for sugar maple with plain dowels.

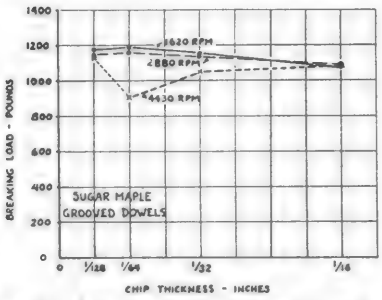

Fig. 8.—Breaking load vs. chip thickness for sugar maple with spiral grooved dowels.

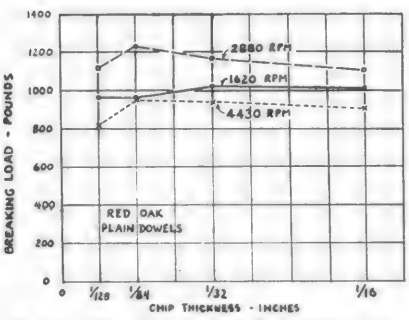

Fig. 9.—Breaking load vs. chip thickness for red oak with plain dowels.

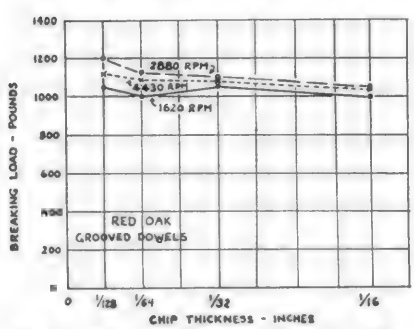

Fig. 10.—Breaking load vs. chip thickness for red oak with spiral grooved dowels.

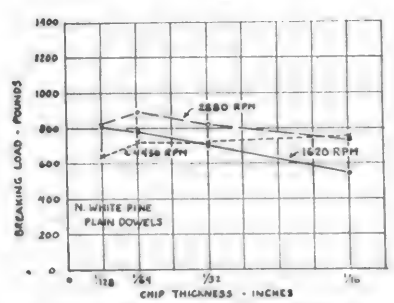

Fig. 11.—Breaking load vs. chip thickness for northern white pine with plain dowels.

group sizes for all rpm-chip thickness classifications in each of the dowel-species groups were reduced when necessary, to exclude failures occurring outside the test blocks. The sample groups were reduced to six specimens, by random methods, for sugar maple with plain dowel joints, and for sugar maple and red oak with spiral grooved dowels. The red oak groups with plain dowels and the northern white pine groups with both plain and spiral grooved dowels were not reduced in size because no load block failures or dowel failures outside of the test block developed.

The possibility of joint failures in the load blocks was recognized in planning the experiment and sample groups of ten were selected to assure final group sizes of at least five. This procedure was necessary to permit using standard 3/8-inch by 2 1/2-inch dowels. A longer dowel would have permitted insertion to a depth of 2 inches in the load block and would probably have eliminated load block failures. The dowel failures between blocks would have remained a problem. The 2 1/2-inch dowel length was a standard size from our sources of dowel supply, whereas longer 3/8-inch dowels were not readily available.

Chip Thickness Effects: Detailed statistical treatment of results is not included in this report. The six analyses of variance are summarized in Table 2. These analyses show that there was no significant difference between breaking loads due to differences in chip thickness, for the sugar maple specimens with either plain or spiral grooved dowels. The graphs of breaking load versus chip thickness presented in Figs. 7 and 8 might well be a series of horizontal lines, one for each rpm.

The breaking loads of the red oak test specimens showed no significant differences due to chip thickness, for the plain dowels. However a high level of significance was displayed for the red oak specimens with spiral grooved dowels. These results are presented graphically in Figs. 9 and 10.

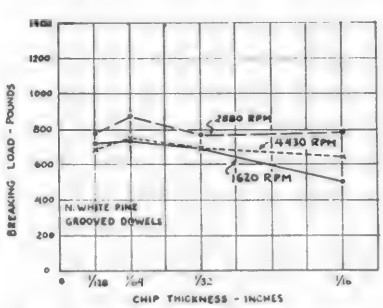

Fig. 12.—Breaking load vs. chip thickness for northern white pine with spiral grooved dowels.

The graphs in Fig. 10 show consistent trends of strength loss with increasing chip thickness. This effect is not great and the significance indicated by the analysis of variance is due principally to the marked change in breaking load between 1/128- and 1/64-inch chip thickness in the 2880 and 4430 rpm data. The change in joint strength due to chip thickness is certainly not of great magnitude in the range covered by this study. The trend, however, is definite.

The analyses of variance results shown in Table 2 show that significant differences in breaking loads attributable to chip thickness are present for northern white pine joints made with either type of dowel. Northern white pine is a low density species and bundles of fibers tear more easily from the wall surfaces. This machining defect becomes increasingly severe as the chip thickness is increased.

All of the data was analyzed more critically by means of "t" tests.

Effects of Speed of Rotation: One outstandingly consistent result was the position of the 2880 rpm curve in Figs. 7 through 12. The joint strength for specimens bored at 2880 rpm were usually higher than the strength of the specimens bored at 1260 and 4430 rpm. The boring rpm was found to influence joint strength to a greater extent than did the chip thickness or hole wall roughness. The data in Table 2 shows that significant differences in breaking load are more common when results are compared with respect to rpm than when compared on a basis of chip thickness.

Breaking load versus rpm results are presented graphically in Figs. 13 through 18. The analyses of variance for the sugar maple specimens (Table 2) showed significant effects of rpm on the breaking loads (Figs. 13 and 14). Detailed analysis by "t" tests was

Table 2.—SUMMARY OF ANALYSES OF VARIANCE OF BREAKING LOADS FOR THE SIX DOWEL TYPE-SPECIES COMBINATIONS

Species and Dowel Type	Source of Variation: Between chip thickness	Between rpm	Interaction
Sugar maple—			
plain dowel	N.S.	S.	N.S.
spiral-grooved dowel	N.S.	S.	N.S.
Red oak—			
plain dowel	N.S.	S.	N.S.
spiral-grooved dowel	S.	S.	N.S.
Northern white pine—			
plain dowel	S.	S.	S.
spiral-grooved dowel	S.	S.	S.

N.S. = No significant difference at the 5 per cent level.

S. = Significant difference at the 5 per cent level. All significant results were also significant at the 1 per cent level except sugar maple, spiral grooved dowel (between rpm) which was significant at the 2 per cent level.

interpreted to indicate a loss in strength at 4430 rpm. This was strongly evident for the plain dowel joints. The data for the spiral grooved dowel joints in sugar maple was significant of a real strength loss at 4430 rpm for the 1/64-inch chip thickness only. However, in view of the significant differences between breaking loads for joints with the holes bored at 2880 and 4430 rpm for other specimens involved in this study, it is believed that the relationship of strength loss at higher boring speeds is a real one.

The results plotted in Figs. 15 through 18 for red oak and northern white pine show that highest breaking loads occurred at 2880 rpm.

These results indicate that some optimum boring speed exists for each species and that extremely high or extremely low boring speeds cause poor hole wall surfaces for glue joints. Of the three speeds used in these tests, the 2880 rpm speed was the most suitable.

It is believed that the relationship between rpm and breaking load has been established. It is worthy of note that the superior joint strength for specimens bored at 2880 was often quite appreciable.

Factors Affecting Results: The factors of hole wall roughness and overheating have been discussed under "General Considerations". The expected effect of the roughness was reduced joint strength with increasing roughness of the walls. This effect was found significant for the red oak blocks with spiral grooved dowels and the northern white pine blocks with either plain or spiral grooved dowels. The lack of significance of this effect for the sugar maple specimens is attributed to the high and uniform density of the species and the heating effect associated with small chip thickness. This heating effect would counteract any favorable influence of smoother wall surfaces at small chip thicknesses.

Wall quality is smoother and more uniform over a given range of chip thickness for species, such as sugar maple, which have high and uniform density, than for species of low density or having considerable density variation. Red oak is a ring-porous wood with bands of medium density springwood alternating between bands of higher density summerwood. This favors tear-out of fibers in the springwood areas, particularly at large chip thickness feed rates.

Northern white pine is a low density species with strength properties somewhat lower than the other two species tested. The tear-out of fibers along the hole wall is greatly influenced by chip thickness for wood of this type. This can be observed in the appearance of the holes and is reflected in the analysis of variance results for chip thickness vs. joint strength.

Markedly reduced joint strength at small chip thicknesses are attributed to overheating. The heat balance in the boring process is helpful in explaining these results.

The temperature attained by the tool depends upon the heat generated by the cutting action and the balance between heat gained by the tool and that lost to the wood, the air and the boring spindle, chuck, and other machine parts.

If the effect of tool rpm is excluded from the discussion, the heat generated in cutting will depend upon:

(a) density and moisture content
(b) chip thickness
(c) duration of cutting action
(d) diameter of the hole
(e) depth of the hole
(f) design of the tool

The energy required to cut wood is related to its density and strength properties. The moisture content affects the strength properties, which decrease with increasing moisture content. Moisture content was closely controlled and would have no influence on the comparisons of results in this investigation.

For chips of equal thickness, the heat generated in boring high density species exceeds that for low density species. This must be a general statement because the number of species studied to date is small.

Chip thickness in boring, as in other wood machining processes, has an influence on the force required and on the heat developed. The rate of heat evolution increases with increasing chip thickness since the work involved in separating the chip is directly related to chip thickness. One should recognize that the use of feed speeds which produce extremely fine chips may result in compression as well as cutting, with attendant high frictional heat.

Some studies of boring power vs. chip thickness have shown that the power vs. chip thickness curves are straight lines with positive intercepts on the power axis. From this it can be seen that the total energy (energy equals power × time) required to bore a hole a definite depth is greater for small chip thickness feed rates than for large ones. This is reflected in greater heat evolved for the small chip thickness boring operation. This seems reasonable since it should take more energy to reduce a given amount of wood to fine chips than to large

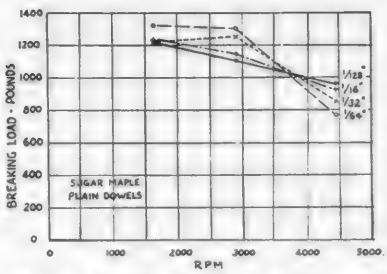

Fig. 13.—Breaking load vs. rpm for sugar maple with plain dowels.

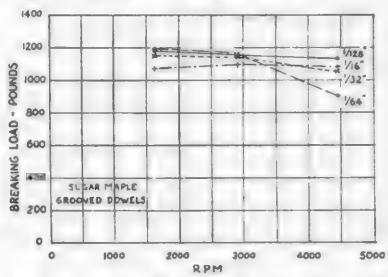

Fig. 14.—Breaking load vs. rpm for sugar maple with spiral grooved dowels.

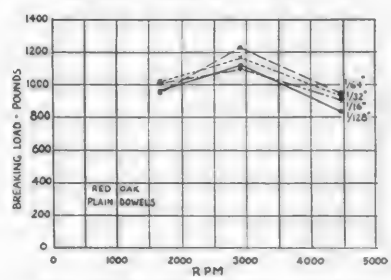

Fig. 15.—Breaking load vs. rpm for red oak with plain dowels.

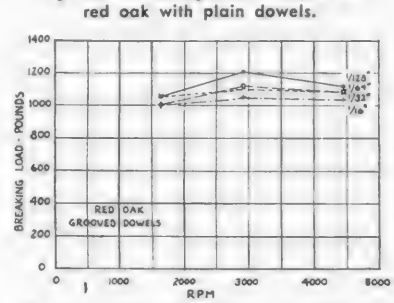

Fig. 16.—Breaking load vs. rpm for red oak with spiral grooved dowels.

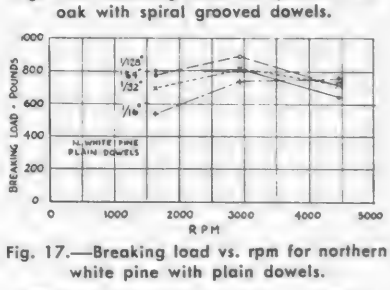

Fig. 17.—Breaking load vs. rpm for northern white pine with plain dowels.

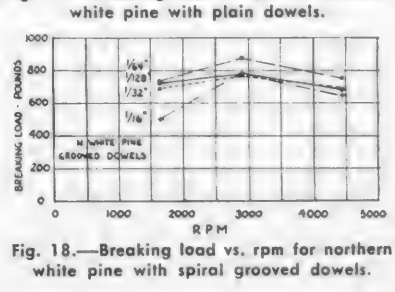

Fig. 18.—Breaking load vs. rpm for northern white pine with spiral grooved dowels.

ones. This is an important point to remember—although less energy is used in producing a small chip than a large one, the relationship is not of direct proportionality. It is more economical to accomplish a given cutting job with the largest chip thickness that quality considerations will permit, than to resort to fine chip thickness which will use more energy and develop more heat in accomplishing an acceptable result.

The interrelationship of chip thickness and duration of cutting (i.e., time the tool is in the cut) influences heating of the hole wall surface. At any given rpm, a low feed speed produces a thin chip and the tool is in the cut for a longer period of time than would be the case if a high feed speed was used. As explained above, more heat is evolved in the former case by the cutting action itself. Heat due to friction between the side wall of the hole and the tool, or the severed chips in the gullets of the tool, prevails over a more extended period of time at low feed rates. This allows more time for the wood in the wall surfaces to pick up heat.

Tool designs to relieve purely frictional contact between the tool and the wood should present advantages from both the wear and heating viewpoints.

The temperature rise of the tool will depend upon its mass. For equivalent cutting angles and tool diameters, low mass tools will operate at higher temperatures than tools with large mass. Low mass tools have less material to be heated, hence they attain greater temperatures for a given amount of developed heat.

The portion of the heat attributable to the pure rubbing action of the points and spurs would be greater for small diameter spur machine bits than for large ones. The spurs and points may be responsible for the major portion of the heat generated by small diameter tools. Some interesting results on power attributable to spurs and points of one inch boring bits have been obtained by Goodchild.[6]

Much of the heat loss in boring occurs during the periods between cuts, when the bit is withdrawn from the wood. Boring tools operated at high production rates run at higher temperatures than those operated at lower frequency. Long periods between cuts facilitate cooling of the tool and result in lower operating temperatures. Short cooling periods lead to high tool temperatures, high maintenance costs, short tool life, and poor quality holes for gluing purposes.

[6] See footnote 2.

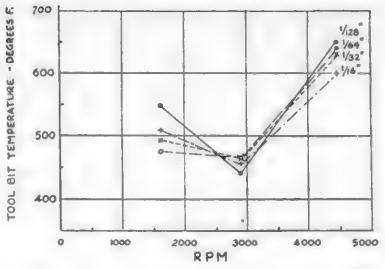

Fig. 19.—Tool bit temperature vs. rpm for various chip thicknesses, using a ½-inch diameter bit in yellow birch.

The effect of boring speed on the temperature of a ½-inch tool bit is shown in Fig. 19. The data plotted on this graph are from another investigation currently in progress. These results were obtained for yellow birch bored at a frequency of 15 holes per minute. They indicate that there is probably an optimum range of boring rpm corresponding to minimum tool temperatures.

In explanation of this behavior, one might consider that at high rpm the heat is generated rapidly and the time available for its dissipation is short. High temperature gradients exist near the cutting edges and in the point of the tool. At lower boring speed, the heat is generated slowly and more time is available for its dissipation.

In terms of wood-glue joint strength, the tool temperature occurring at high boring rpm would lead to overheating, affecting the polarity of the wood, and consequently the bond at the wood-glue interface. This is helpful in explaining the reduction in joint strength observed in Figs. 13 through 18 at 4430 rpm. However, it does not explain the reduced strengths at 1620 rpm which appear in Figs. 15 through 18.

A possible explanation of this reduction in joint strength at low rpm may be that, although the tool temperature is reasonably low, the contact time between the bit and the wood is long. This long exposure to the heat of the bit may well cause sufficient heating of the wood to affect polarity. This theory would indicate that optimum boring rpm would be an intermediate range between the high and low rpm used in this investigation.

Conclusions

This investigation has shown that the surface quality of the wall of a bored hole is affected by the thickness of chips removed during the boring process and the speed of rotation of the boring tool. The chip thickness has less effect on physical roughness of the hole wall for species of high and uniform density than for species having low density material in both springwood and summerwood, or in springwood areas alone.

The ruptured fibers in the wall surfaces of low density species, bored with high feed speeds and large chip thickness, materially weaken the wood-glue bond in dowel joints. Species having high and uniform density are less subject to tear-out of the hole wall fibers than low density species, when thick chips are cut. Consequently the wood-glue bond in doweled joints is not materially weakened by the heavier cuts, in species of high density and uniform structure.

Boring rpm has a greater influence on the strength of doweled joints than does chip thickness. The rotational speed of the tool is shown to influence dowel joint strength through its effect on the temperature of the wood.

Low strength of dowel joints bored at high tool rpm is attributed to the rapid generation of heat in cutting. This heat cannot be conducted away as fast as it is generated, hence the tool temperature increases and overheats the wood.

Low strength of dowel joints bored at low tool rpm is attributed to the long exposure of the hole wall to bit temperatures much lower than those attained at the high boring speeds.

Overheating affects the surface of the wood and weakens the bond at the wood-glue interface, presumably due to its effect on polarity of the wood.

On the basis of these tests, 2880 rpm was the optimum boring speed and 1/64 to 1/32 inch was the optimum chip thickness range. These chip thicknesses correspond to feed speeds of 90 to 180 inches per minute. This study was not intended to establish definite optimum boring speeds. Such a work would require collecting additional data at more closely spaced intervals over the range of boring speeds used in this study, for more species, dowel sizes, tool styles, and depths of holes. The primary purpose of this work was to explore the general relationships and to show where additional research will yield useful results.

Tests showed no evidence of a significant difference between dowel types (plain or spiral grooved) in their effect on joint strength.

Polyvinyl acetate adhesives are believed to be less sensitive to hole wall roughness than most other woodworking glues. For this reason it would be likely that tests using other glues for the bonding agent might show effects of chip thickness more strongly. Polyvinyl acetate was used in this work because it is a popular adhesive for dowel joint construction.

The fact that boring speeds and

chip thicknesses can influence joint strength should be of considerable interest to research workers who are using dowel joints in evaluating glues. It suggests that hole boring speeds and feeds should carefully be selected and controlled in preparing test material.

Acknowledgments

The writer wishes to express his appreciation for the able assistance of W. P. Johnson, who carried out much of the testing work and computation work for the statistical analyses. The help provided by Dr. John M. Yavorsky in selection of statistical methods and interpretation of results is greatly appreciated. The writer wishes to extend thanks to A. W. Hawkinson of Greenlee Tool Co. and Donald K. Saunders of Saunders Brothers Co. for their assistance and support.

An Analysis of the Lumber Planing Process: Part II[1, 2]

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This study is Part II of an investigation pertaining to the peripheral-milling process of planing lumber. Some relationships were determined between cutterhead horsepower and various combinations of specimen, cutterhead, and feed factors. Power demand curves were interpreted through comparison with simultaneously taken one micro-second photos of the forming chips. Secondary consideration was given to the quality of surface obtained. The cutterhead variables, feeds, and speeds employed are in the range of those commonly used in industry, i.e., feed speeds to 500 FPM with cutterheads ranging up to 9-inch cutting-circle diameter and carrying up to 8 knives.

THIS DISCUSSION is a continuation of a previous report (4)[3] on fundamental information pertaining to the process of planing lumber. The previous report dealt with the influence of the following factors: number of jointed knives cutting, rake angle, clearance angle, cutterhead type, feed speed, depth of cut, grain type, and moisture content.

The present report discusses cutterhead horsepower demand in a series of six experiments with factors outlined as follows:

Test Able—*Cutting circle diameter,* number of jointed knives cutting, per cent moisture content, and feed speed.

Test Easy—*Specific gravity,* depth of cut, and feed speed.

Test Fox—*Angle between rotational axis of cutterhead and direction of feed,* and depth of cut.

Test George—*Direction of cutterhead rotation with relation to direction of feed,* and depth of cut.

Test How—*Knife extension beyond face of gib.*

Test Ivy—*Width of joint,* and depth of cut.

The kinematics of the process and testing technique, together with preliminary discussions of specimen selection, surface analysis, knives, and cutterheads, are omitted from this report inasmuch as this material was introductory to Part I (4).

Test Results and Discussion

A. Test Able: This four-factor experiment was designed to study the interaction of the variables of cutting-circle diameter, number of jointed knives cutting, per cent moisture content, and feed speed.

The choice of cutting circles was somewhat limited by the necessity of using identical gibs, rake angle, clearance angle, and knife extension on the heads selected. For this reason, the variable of cutting circle diameter was restricted to the consideration of only two values, i.e., 9.02 and 7.63 inches. It might be noted that both of these diameters are popular on 8-knife planers and matchers in industry.

Having chosen heads slotted for eight knives, possibilities for numbers of jointed knives cutting were limited to eight, four, and two. To use a number of knives less than eight simply involved setting back the excess knives to a point where they would not touch the workpiece. The remaining knives were not rejointed after setting back the excess knives, and the resulting knife traces indicated that in each case the joint remained good.

The specimen was tested both dry and green. The dry specimen reached an equilibrium moisture content of 8.2 per cent after several weeks in the laboratory. The green specimen had a moisture content of approximately 82 per cent. The procedure of accomplishing cell wall saturation of the green specimen by pressure treating it in water for eight days at approximately 65 psi resulted in the presence of considerable free water in the cell cavities. The 82 per cent moisture content probably is closer to an approximation of green Douglas-fir sapwood moisture content than it is of the heartwood which made up the specimen. Between tests which extended over several days, the green specimen was submerged in a shallow water tank in order to prevent it from drying out.

Table 1.—RESUME OF FACTORS APPLYING TO TEST ABLE

Variable Factors:
- Cutting-Circle Diameter in Inches: 9.02 and 7.63
- Number of Jointed Knives Cutting: 2, 4, and 8
- Percent Moisture Content (based on O. D. weight):
  - Dry, i.e., 8.2 ±0.4
  - Green, i.e., 82.0 ±15.0
- Feed Speed in FPM: Average values 108, 204, 306, 407, and 503

Fixed Factors:
- Specimen:
  - General Description: The test pieces consisted of two eighteen-foot-long 1 by 3's ripped from the central portion of a single, dry (10 percent M.C.), 1 by 6 board. One of these was pressure treated in water at approximately 65 psi for a period of eight days to simulate the green condition.
  - Species: Pseudotsuga taxifolia
  - Wood Type: Heart
  - Rings per Inch: 22 ±4
  - Width of Machined Surface: 0.798 ±0.016
  - Angle of Annual Rings to Machined Surface:
    - Dry specimen: 45 ±1 degrees
    - Green specimen: 30 ±10 degrees
  - Spiral Grain: 3/8 inch per foot favoring feed
  - Specific Gravity: Based on O.D. weight and green volume 0.446 ±0.01, Based on O.D. weight and O.D. volume 0.482 ±0.02
  - Inclination of Diagonal Grain to Direction of Feed: None
- Cutterhead:
  - Head Bodies: Jointer type slotted for 8 knives, 9.02-inch cutting circle; Jointer type, slotted for 8 knives, 7.63-inch cutting circle
  - Gibs: Concave face
  - Knives: 3/8-inch thick with corrugated back
  - Rake: 30 degrees
  - Clearance: 20 degrees
  - Knife Extension beyond Gib: 0.344 ±0.015 inches
  - Width of Joint: 0.011 ±0.002 inches
  - Nominal RPM of Cutterhead: 3600
- Feed:
  - Depth of Cut: 0.0625 inches

[1] Presented at Session IX, Wood Machining, FPRS Ninth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] Based on a dissertation submitted in partial fulfillment of requirements for Ph.D. degree at College of Forestry, U. of Washington, Seattle.

[3] Numbers in parentheses refer to literature cited.

The Author: Peter Koch received B.S. from Montana State College, Ph.D. from U. of Washington. He was assistant to the president, Stetson-Ross Machine Co., from 1946–52; consulting engineer from 1952–55, when he accepted present position.

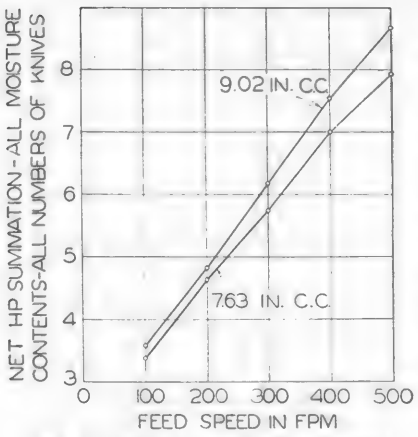

Fig. 1.—Relative net horsepower requirement for wood removal under Test Able conditions comparing 9.02-inch and 7.63-inch cutting-circle diameters at varying feed speeds (ignoring factors of moisture content and number of knives).

The feed speed was varied in approximately 100 FPM increments from 100 to 500 FPM. While it is apparent that 100 FPM is a relatively slow feed speed for an 8-knife machine, and that 500 FPM is an impractical high speed for a 2-knife machine, the extreme range provides a family of data suitable for plotting and analysis. The fixed factors involved as well as the variable factors are outlined in Table 1.

Photographs of this test were limited to the green specimens machined with the 7.63-inch cutting-circle cutterhead, inasmuch as a rather complete set of photographs had been taken on the prior Test Dog which involved two of the same variable factors, i.e., number of knives and feed speed (4). The tabulation of the horsepower requirements is presented in Table 2.

Table 3 shows the combination of factors that produce satisfactory surfaces as previously defined (4). It is evident that high speeds with few knives have an adverse effect on the surface conditions. The green specimens provided the best surfaces under adverse conditions when compared to dry specimens. The controlling defect for both green and dry specimens was the amount of torn grain with considerable chip marking being evident on both green and dry samples. Fuzzy grain was not an important factor, and no raised grain was evident on any of the specimens under any combination of factors.

A perusal of the tabulation of graphs of cutterhead horsepower data reveals that, in a summation of all factor combinations, the 9.02-inch cutting-circle head requires 7.35 per cent more power than the 7.63 inch cutting-circle head (refer to Fig. 1). The larger cutting-circle head required 10.8 per cent more power on green stock than did the smaller head. On dry stock, the difference was not so marked, being only 3.37 per cent.

Because the 9.02-inch diameter head has an 18.2 percent longer moment arm than the 7.63-inch diameter head, each knife is in the cut a relatively shorter length of time. Therefore, the increased moment is nearly cancelled by decreased knife time in the cut. The compensation is not complete, however, because the length of knife engagement of the 9.02-inch cutterhead at 300 FPM and 1/16-inch depth of cut is 0.780 inches, compared with the 7.63-inch cutterhead length of path engagement of 0.726 inches under the same conditions (7), i.e., an increase of 7.44 per cent.

Furthermore, the larger head has a peripheral speed of 8,150 FPM compared to 6,900 FPM for the smaller head. This additional velocity increases the accelerational force exerted by the chip as it forms and therefore raises the horsepower requirement.

The knife path lengths previously mentioned are associated with an average chip thickness for the 7.63-inch cutterhead of 0.01123 inches, and an average chip thickness for the 9.02-inch cutterhead of 0.01045 inches (7), or a decrease of 6.9 per cent in average chip thickness.

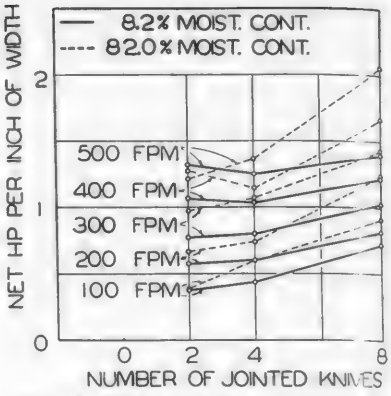

Fig. 2.—Net horsepower requirement for wood removal under Test Able conditions for a 9.02-inch diameter cutting-circle cutterhead comparing green and dry requirements with varying feed speeds and number of knives.

The 7.35 per cent more power required by the large cutterhead (all factors considered) is attributable to a combination of the following factors:

a. A 7.44 per cent increase in knife path engagement length.
b. An 18.2 per cent increase in knife velocity (causing an emphasis of power demand differential with green stock as compared with dry stock).
c. A 6.9 per cent decrease in average chip thickness.

The effect on the power requirement of a varying number of knives in the head depends to a great extent on the feed speed and on the moisture content of the specimen. The frequently made assumption that the power demand is a straight line function of the number of knives employed and that, under any given set of feed conditions, doubling the number of knives will double the horsepower requirement, is shown to be of dubious validity. On dry stock it is evident with both cutting-circle diameters that horsepower is proportional

Table 2.—NET HORSEPOWER REQUIREMENT FOR WOOD REMOVAL FROM 1" WIDE STOCK UNDER TEST ABLE CONDITIONS*

	Cutting-Circle Diam. in Inches							
	9.02				7.63			
	Dry		Green		Dry		Green	
No. of Knives	Net HP	Feed Speed FPM	Net HP	Feed Speed FPM	Net HP	Feed Speed FPM	Net HP	Feed Speed FPM
2	1.34	504	1.21	505	1.21	505	1.36	501
	1.08	407	1.31	408	1.03	406	1.08	409
	0.80	309	0.99	306	0.78	306	0.87	305
	0.59	206	0.67	203	0.55	204	0.65	203
	0.40	109	0.42	109	0.31	108	0.42	108
4	1.27	505	1.38	504	1.32	507	1.30	500
	1.06	407	1.15	407	1.10	408	1.13	405
	0.81	307	1.08	306	0.73	304	0.97	306
	0.61	203	0.75	206	0.69	203	0.80	203
	0.46	108	0.63	109	0.43	107	0.58	107
8	1.42	504	2.06	498	1.30	506	1.43	502
	1.24	404	1.70	409	1.20	406	1.46	404
	1.03	305	1.46	308	1.09	305	1.32	305
	0.94	209	1.27	204	0.87	202	1.09	204
	0.75	108	0.93	108	0.74	108	0.90	108

*Refer to Table 1 for resume of factors.

Table 3.—COMBINATIONS OF FACTORS UNDER TEST ABLE CONDITIONS THAT PRODUCED SATISFACTORY PLANED SURFACES

		Cutting Circle Diam. in Inches			
		9.02		7.63	
No. of Knives	Feed Speed FPM	Dry	Green	Dry	Green
2	503	-----	-----	-----	-----
	407	-----	-----	-----	-----
	306	-----	-----	-----	-----
	204	-----	-----	-----	-----
	108	-----	*	-----	-----
4	503	-----	-----	-----	-----
	407	-----	-----	-----	-----
	306	-----	*	-----	-----
	204	-----	*	-----	-----
	108	*	*	*	*
8	503	-----	*	-----	*
	407	-----	*	-----	*
	306	-----	*	-----	*
	204	*	*	*	*
	108	*	*	*	*

*Asterisk indicates satisfactory surface.

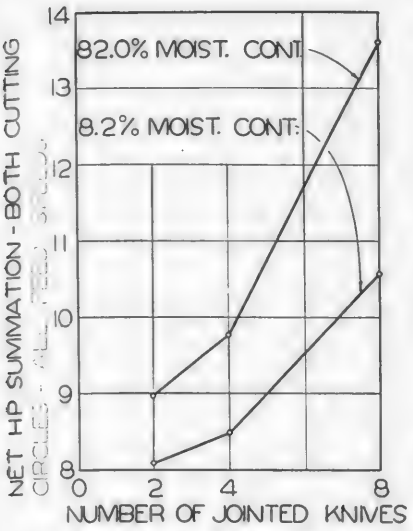

Fig. 3.—Relative net horsepower requirement for wood removal under Test Able conditions comparing 82.0 per cent and 8.2 per cent moisture content specimens machined with a varying number of jointed knives (ignoring factors of cutting-circle diameter and feed speed).

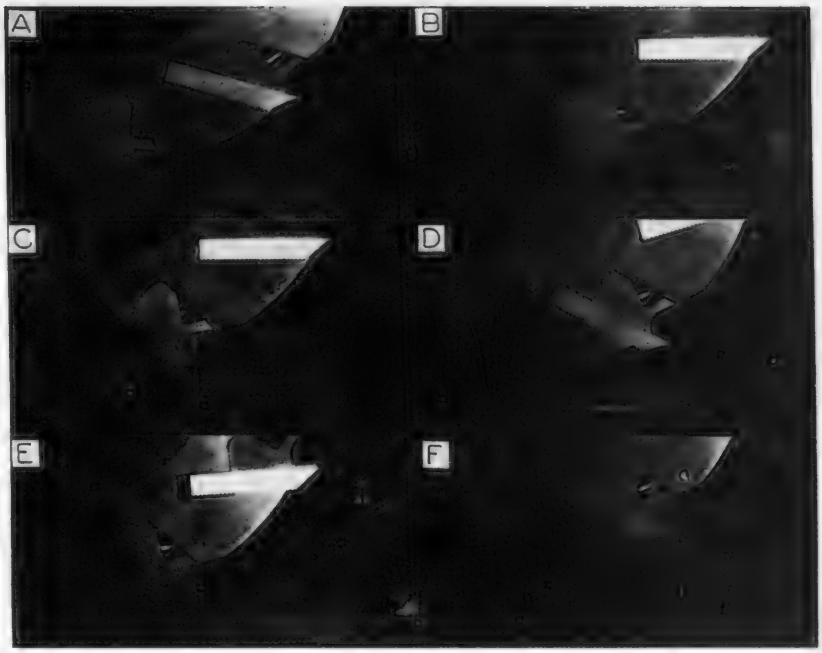

Fig. 7.—Test Able. (A) Number of knives: 2; feed speed: 200 FPM; moisture content: green; cutting-circle diam.: 7.63 inch. (B) Number of knives: 2; feed speed: 400 FPM; moisture content: green; cutting-circle diam.: 7.63 inch. (C) Number of knives: 4; feed speed: 100 FPM; moisture content: green; cutting-circle diam.: 7.63 inch. (D) Number of knives: 4; feed speed: 200 FPM; moisture content: green; cutting-circle diam.: 7.63 inch. (E) Number of knives: 8; feed speed: 400 FPM; moisture content: green; cutting circle diam.: 7.63 inch. (F) Number of knives: 8; feed speed: 500 FPM; moisture content: green; cutting-circle diam.: 7.63 inch.

to number of knives only at low speeds, and then only roughly so. As the feed speed increases, the power requirement becomes more nearly constant regardless of the number of knives employed. This is illustrated in Fig. 2. The reason for this relationship was discussed more fully with the aid of photographs in the previous article (4). It is sufficient to say here that the *extreme* advance splitting that takes place with few knives at high speeds causes a type of higher energy chip deformation than that occurring when a greater number of knives is used.

With the green specimens, a more marked proportionality between horsepower requirement and number of knives is noted. Figs. 7A through 7F indicate that regardless of the feed speed or number of knives employed, a reasonably coherent chip is formed. Due to the increased plasticity of the green wood, the chip is less subject to advance splitting, and hence it is logical that for any given feed speed, fewer knives will require less power, for the reason that a larger chip is removed by each knife, with correspondingly fewer chips and fewer fibers requiring severance.

Figs. 2 through 6 show that the green specimens take significantly more power than do the dry specimens. As previously commented (4), part of the explanation lies in the fact that the additional weight of the green chip, due to both its free and adsorbed water, increases the force necessary to accelerate it to cutterhead velocity. Other things being equal, this increase in force would be directly proportional to the increase in mass of the undeformed chip. The change in velocity is considerable, inasmuch as in conventional milling or up-milling, (which applies to this test), the stock and the undeformed chip are traveling in one direction at a speed up to 500 FPM, whereas the knife which must pick up the deformed chip is traveling at approximately 8000 FPM in the opposite direction. The transition from

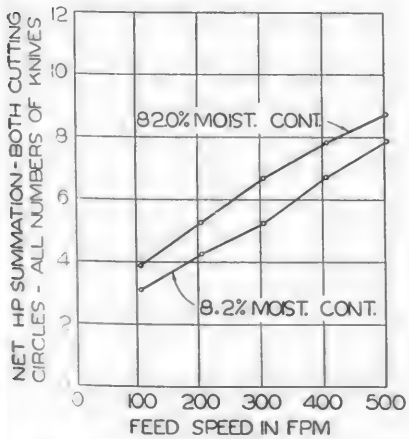

Fig. 4.—Relative net horsepower requirement for wood removal under Test Able conditions comparing 82.0 per cent and 8.2 per cent moisture content specimens at varying feed speeds (ignoring factors of cutting-circle diameter and number of knives).

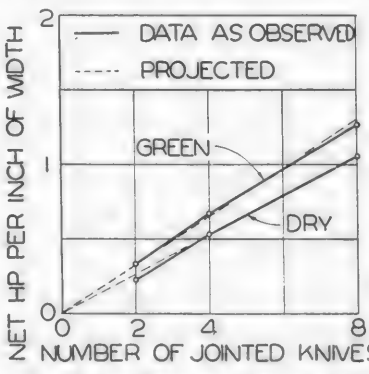

Fig. 5.—Net horsepower requirement for wood removal under Test Able conditions comparing 2, 4, and 8 knife requirements for a surface quality of 8 knife marks per inch using a 7.63-inch diameter cutting-circle cutterhead machining both green and dry wood.

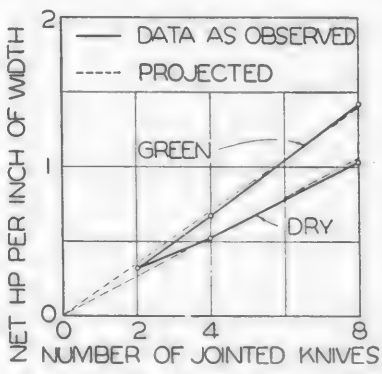

Fig. 6.—Net horsepower requirement for wood removal under Test Able conditions comparing 2, 4, and 8 knife requirements for a surface quality of 8 knife marks per inch using a 9.02-inch diameter cutting-circle cutterhead machining both green and dry wood.

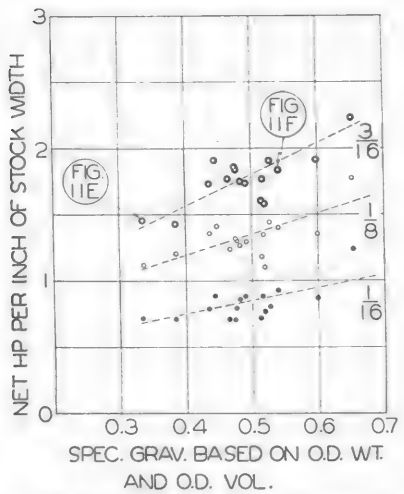

Fig. 8.—Net horsepower requirement for wood removal under Test Easy conditions comparing 1/16, 1/8, and 3/16 inch depth cuts at 150.5 FPM and at varying specific gravities.

attached undeformed chip with a velocity of −500 FPM to unattached deformed chip with a velocity of +8000 FPM takes place within a distance of approximately ¾ inch, the exact distance depending on cutterhead and feed conditions.

Considering all readings of green and dry horsepower values, the green stock required 19.2 per cent more power than the dry stock. Using the 9.02-inch cutting-circle head, the green specimens required 23.3 per cent more power than the dry specimens. Using a 7.63-inch cutting-circle head, the green samples took 15.0 per cent more power than the dry samples.

If the variables of cutting-circle diameter and feed speed are ignored, cutting green stock with two knives required 11 per cent more power than cutting dry stock with two knives. With four knives the green specimens required 15.2 per cent more power than the dry specimens, and with eight knives the green stock required 28.8 per cent more power than the dry stock. This is illustrated in Fig. 3.

Fig. 4 illustrates that if only feed speed and moisture content are considered, green stock shows less percentage power penalty at 500 FPM than it does at 100 FPM feed speed.

A typical chip from a green specimen is shown in Fig. 7B. The shaving is coherent with no advance splitting taking place until the instant before the chip is detached, at which point the harder summerwood of the annual rings splits slightly, giving the comb appearance shown. Fig. 7E shows the abrupt deformation that takes place in the chip as a result of gib shape.

Figs. 5 and 6, which show horsepower requirements with varying numbers of knives but at a constant surface quality of eight knife marks per inch, and a constant depth of cut of 1/16 inch, reveal an approximate straight line relationship that can be expressed

Table 4.—RESUME OF FACTORS APPLYING TO TEST EASY

Variable Factors:
- Specific Gravity: Sixteen values from 0.334 to 0.651 based on O.D. volume and O.D. weight
- Depth of Cut in Inches: 1/16, 1/8, and 3/16
- Feed Speed in FPM: Average values 150.5 and 306.7

Fixed Factors:
- Specimen:
  - General Description: The test pieces consisted of sixteen different surfaced, dry, eighteen-foot-long 1 by 3's of varying specific gravity, but with similar grain and annual ring orientation
  - Species: Pseudotsuga taxifolia
  - Wood Type: Heart
  - Rings per Inch: Average 28, standard deviation ±13
  - Width of Machined Surface: Average 0.778 inches
  - Angle of Annual Rings to Machined Surface: 43 ± 18 degrees
  - Spiral Grain: Average 5/16 inch per foot favoring direction of feed
  - Percent Moisture Content (based on O.D. weight): 8.5 ± 1.1
  - Inclination of Diagonal Grain to Direction of Feed: None
- Cutterhead:
  - Head Body: Jointer type, 8-knife, 9.03-inch cutting circle
  - Gibs: Concave face
- Knives: 5/16-inch thick with corrugated back
  - Number of Knives: 8
  - Cutting-Circle Diamater in Inches: 9.03
  - Rake: 30 degrees
  - Clearance: 20 degrees
  - Knife Extension beyond Gib: 0.33 inches
  - Width of Joint: 0.008 ± 0.003 inches
  - Nominal RPM of Cutterhead: 3600

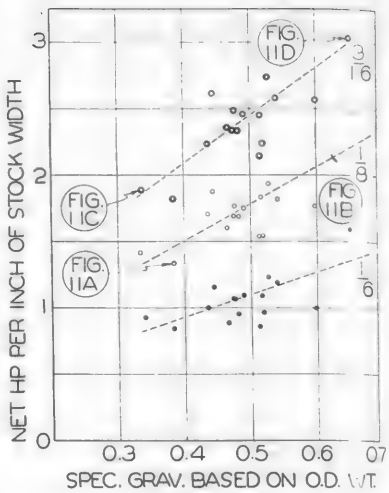

Fig. 9.—Net horsepower requirement for wood removal under Test Easy conditions comparing 1/16, 1/8, and 3/16 inch depth cuts at 306.7 FPM and at varying specific gravities.

$$W_n = CT$$

where

W_n = net horsepower requirement per inch of stock width

T = number of knives

C = a constant having the values

	9.02-inch diameter cutting-circle	7.63-inch diameter cutting-circle
dry	0.131	0.131
green	0.175	0.163

B. Test Easy: This three-factor experiment was designed to study the interaction of the variables of specific gravity, depth of cut, and feed speed.

The 16 specimens involved were purchased in a dry, surfaced condition and allowed to reach an equilibrium moisture content of 8.5 per cent. The specific gravity of the specimens (based on oven-dry weight and oven-dry volume) ranged from 0.334 to 0.651. A considerable effort was made to select boards of varying spe-

Table 5.—NET HORSEPOWER REQUIREMENT FOR WOOD REMOVAL FROM 1" WIDE STOCK UNDER TEST EASY CONDITIONS*

Specimen No.	Specific Grav.†	Depth Cut 1/16 Average Feed Speed FPM 150.5	Depth Cut 1/16 Average Feed Speed FPM 306.7	Depth Cut 1/8 Average Feed Speed FPM 150.5	Depth Cut 1/8 Average Feed Speed FPM 306.7	Depth Cut 3/16 Average Feed Speed FPM 150.5	Depth Cut 3/16 Average Feed Speed FPM 306.7
1	0.598	0.87	1.00	1.35	1.76	1.92	2.56
2	0.519	0.76	0.97	1.10	1.54	1.58	2.24
3	0.516	0.88	1.09	1.35	1.83	1.77	2.46
4	0.435	0.78	1.00	1.36	1.71	1.73	2.23
5	0.443	0.88	1.16	1.41	1.88	1.92	2.62
6	0.476	0.79	1.07	1.30	1.81	1.84	2.49
7	0.481	0.86	0.96	1.27	1.69	1.75	2.33
8	0.490	0.88	1.09	1.30	1.75	1.74	2.41
9	0.474	0.70	1.07	1.32	1.69	1.86	2.34
10	0.466	0.71	0.88	1.24	1.60	1.77	2.36
11	0.527	0.80	1.23	1.45	1.94	1.92	2.74
12	0.513	0.72	0.86	1.18	1.53	1.60	2.14
13	0.383	0.71	0.84	1.20	1.33	1.43	1.82
14	0.334	0.72	0.93	1.11	1.42	1.46	1.88
15	0.540	0.93	1.19	1.41	1.81	1.84	2.58
16	0.651	1.24	1.59	1.78	2.48	2.24	3.04

*Refer to Table 4 for resume of factors.
†Based on O.D. weight and O.D. volume.

Table 6.—COMBINATIONS OF FACTORS UNDER TEST EASY CONDITIONS THAT PRODUCED SATISFACTORY PLANED SURFACES*

Specimen No.	Specific Grav.†	Depth Cut 1/16 Average Feed Speed FPM 150.5	Depth Cut 1/16 Average Feed Speed FPM 306.7	Depth Cut 1/8 Average Feed Speed FPM 150.5	Depth Cut 1/8 Average Feed Speed FPM 306.7	Depth Cut 3/16 Average Feed Speed FPM 150.5	Depth Cut 3/16 Average Feed Speed FPM 306.7
14	0.334	*	*	*	*	*	*
13	0.383	*	*	*	*	*	*
4	0.435	*	*	*	*	*	*
5	0.443	*	*	*	*	*	*
10	0.466	*		*		*	
9	0.474	*	*				
6	0.476	*		*		*	
7	0.481	*	*	*	*	*	*
8	0.490	*	*		*		
12	0.513	*		*			
3	0.516	*		*		*	
2	0.519	*	*	*	*	*	*
11	0.527	*	*	*	*	*	*
15	0.540	*		*		*	
1	0.598	*		*		*	
16	0.651	*	*	*	*	*	*

†Based on O.D. weight and O.D. volume.
*Asterisk indicates satisfactory surface.

cific gravities but with otherwise similar characteristics, as recorded in Table 4.

Readings were taken at depths of cut of 1/16, 1/8 and 3/16 inches. Feed speeds of 150.5 and 306.7 FPM were utilized. An 8-knife, 30-degree rake angle, 9-inch nominal cutting-circle head with concave-face gibs was employed.

Table 5 is a tabulation of the horsepower requirements. The combinations of factors that produced satisfactory surfaces are shown in Table 6. It can be observed that the combination of fast feeds with deep cuts has an adverse effect on quality of surface. With these particular specimens, the incidence of defective surfaces increased somewhat with increase in specific gravity. Torn grain in local areas of diagonal grain accounted for most of the surface defects, although specimens 8 and 9, which were somewhat resinous, were defective because of excessive chip marking. None of the samples exhibited any fuzzy grain or more than a trace amount of raised grain.

Figs. 8 and 9 show the net horsepower requirements at 150.5 FPM and 306.7 FPM respectively for varying specific gravities and varying depths of cut. In general, the power demand increases with specific gravity, but the relationship is not clearly indicated.

Fig. 10 is a plot of the average net cutterhead horsepower requirement for the two feed speeds involved at depths of cut of 1/16, 1/8, and 3/16 inch. The relationship involved may be expressed as follows:

$$W_n = X + Yd = 0.4 + 0.6\sqrt{V}\ d$$

where

W_n = net cutterhead horsepower requirement per inch of stock width
X = a constant = 0.4
Y = $0.6\sqrt{V}$
V = feed speed in FPM
d = depth of cut in inches

(Note: The above relationship is valid only in the range of d = 1/16 to d = 3/16 inch)

It is apparent that a doubling of depth of cut for either of the two feed speeds considered by no means doubles the horsepower requirement.

In reviewing the pictures of chip formation under Test Easy conditions, it is indicated from a comparison of Figs. 11C and 11D, as well as 11E and 11F, that the chips form under a lesser degree of control, i.e., with more advance splitting, at the higher specific gravities. However, this in itself, unless carried to an extreme degree, should not account for the higher power consumption at higher specific gravities. On the contrary, it might lessen the power consumption. However, the increased mass of the higher specific gravity chip is sufficient in itself to cause a linear increase in power demand, the accelerational force involved being equal to mass multiplied by acceleration. More than this consideration must enter the picture, however, as the strength properties of wood vary with specific gravity (9) according to the general parabolic equation:

$$y = aS^n + b$$

where

y = strength property under consideration
S = specific gravity
a = a constant
b = a constant (zero if it is assumed that wood has no strength at zero specific gravity)
n = a constant

If in this equation b becomes zero and n is taken as unity (6), then the compressive strength parallel to the grain as measured by maximum crushing strength and fiber stress at proportional limit become straight line functions of specific gravity.

In conventional milling (i.e. up-milling) the chip failure in evidence at the initial point of contact involves compressive strength parallel to the grain together with shear parallel to the grain. This type of failure is particularly evident with low rake angles. As the knife moves upward in its path, the action changes to one of shear at an angle to the grain. If advance splitting takes place before the knife emerges from the cut, it is caused by cleavage and failure in tension perpendicular to the grain.

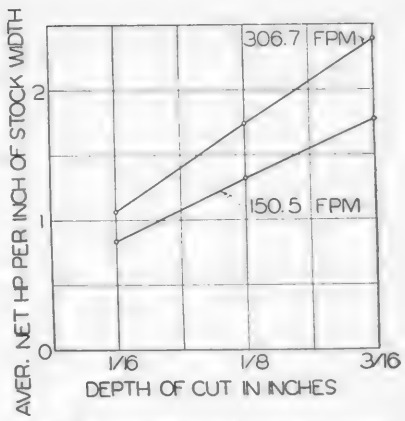

Fig. 10.—Average net horsepower requirement for wood removal under Test Easy conditions comparing feed speeds of 306.7 and 150.5 FPM at varying depths of cut.

Kollman (5) reports that with increasing wood density, or more accurately expressed, with increased shear resistance parallel to the fiber, the planing work and feed force increase.

Kivimaa (3), on parallel to the grain tests involving a multiplicity of species, found that there was a somewhat curvilinear relationship between main cutting force parallel to knife tip motion and specific gravity, i.e, as specific gravity was doubled, the main cutting force increased, but in a lesser proportion.

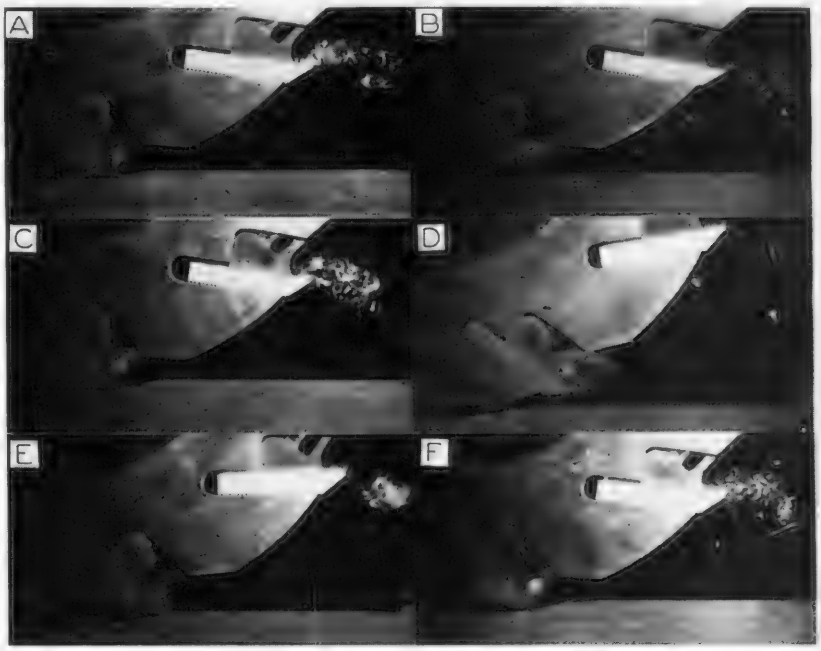

Fig. 11.—Test Easy. (A) Spec. grav.: 0.383; depth cut: 1/8 inch; feed speed: 300 FPM. (B) Spec. grav.: 0.651; depth cut: 1/16 inch; feed speed: 300 FPM. (C) Spec. grav.: 0.334; depth cut: 3/16 inch; feed speed: 300 FPM. (D) Spec. grav.: 0.651; depth cut: 3/16 inch; feed speed: 300 FPM. (E) Spec. grav.: 0.334; depth cut: 3/16 inch; feed speed: 150 FPM. (F) Spec. grav.: 0.540; depth cut: 3/16 inch; feed speed: 150 FPM.

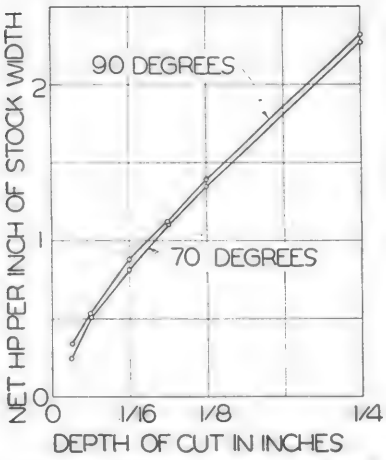

Fig. 12.—Net horsepower requirement for wood removal under Text Fox conditions comparing 90 and 70 degree angles between the rotational axis of the cutterhead and the direction of feed.

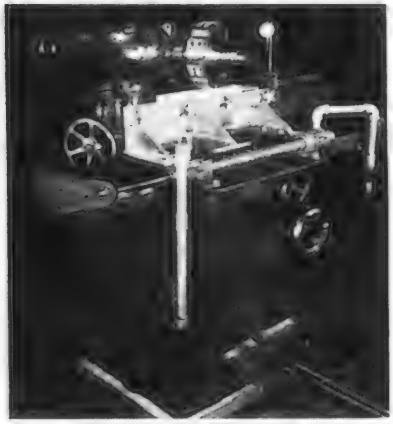

Fig. 13.—Test Fox. Apparatus for planing specimens with the cutterhead rotational axis oriented to any desired angle with relation to the direction of feed.

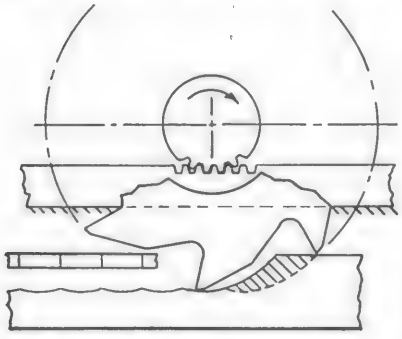

Fig. 14.—Path generated by down-milling cutter knife.

Table 8.—NET HORSEPOWER REQUIREMENT FOR WOOD REMOVAL FROM 1" WIDE STOCK UNDER TEST FOX CONDITIONS*

Depth of Cut in Inches	Angle Between Axis of Cutterhead Spingle and Direction of Feed	
	90 Degrees	70 Degrees
1/64	0.34	0.25
1/32	0.53	0.51
3/32	0.88	0.82
1/16	1.12	1.11
1/8	1.39	1.35
1/4	2.32	2.27

*Refer to Table 7 for resume of factors.

Davis and Nelson (1) found that combined feed and cutterhead power consumption shows a somewhat consistent relationship to specific gravity, the heavier woods in general requiring more power than the lighter ones; however, it is noted that power consumption in machining different woods is not always directly proportional to their specific gravity. Yellow poplar, for instance, requires more power than some heavier woods such as red gum and southern yellow pine.

These findings are not in disagreement with the results reported herein. Between-species comparisons were not tested here.

C. Test Fox: This two-factor experiment was designed to test the interaction of the variables of depth of cut, and the angle between the rotational axis of the cutterhead and the direction of feed. In the execution of this test, an 8-knife, 30-degree rake angle, 9.08-inch cutting-circle cutterhead was used. The feed speed involved was approximately 200 FPM. All readings were taken serially on a single specimen as described in Table 7.

The means of rotating the cutterhead spindle axis to the desired degree is shown in Fig. 13. The short specimen shown in testing position is for illustrative purposes only, as this experiment was conducted using a board 9 feet in length. Readings were taken at depths of cut of 1/64, 1/32, 1/16, 3/32, 1/8, and 1/4 inches.

Table 7.—RESUME OF FACTORS APPLYING TO TEST FOX

Variable Factors:
- Angle between Rotational Axis of Cutterhead and Direction of Feed: (90 degrees and 70 degrees)
- Depth of Cut in Inches: (1/64, 1/32, 1/16, 3/32, 1/8, and 1/4)

Fixed Factors:
- Specimen:
  - General Description: The test piece was a nine-foot-long dry 1 by 3 board.
  - Species: Pseudotsuga taxifolia
  - Wood Type: Heart
  - Rings per Inch: 17 ±2
  - Width of Machined Surface: 0.785 ±0.002 inches
  - Angle of Annual Rings to Machined Surface: 30 ±4 degrees
  - Spiral Grain: None
  - Percent Moisture Content (based on O.D. weight): 8.9 ±0.3
  - Specific Gravity (based on O.D. weight and O.D. volume): 0.374 ±0.008.
  - Inclination of Diagonal Grain to Direction of Feed: None
- Cutterhead:
  - Head Body: Jointer type, 8-knife
  - Gibs: Flat (i.e. not concave) chipbreaking surfaces at right angles to the knife face
  - Knives: 5/16-inch thick with corrugated back
  - Number of Knives: 8
  - Cutting Circle Diameter: 9.08 inches
  - Rake: 30 degrees
  - Clearance: 20 degrees
  - Knife Extension Beyond Gib: 0.344 ±0.010 inches
  - Width of Joint: 0.007 ±0.001
  - Nominal RPM of Cutterhead: 3600
- Feed:
  - Speed: 206 ±2 FPM

No unsatisfactory surfaces were produced by any combination of variables. Table 8 is a tabulation of the horsepower requirements. Fig. 12 presents the data in more easily interpreted form. These data indicate that the slewed cutterhead axis results in a slightly lower power demand. One possible explanation of this situation lies in the fact that the chip in all probability takes a longer path to reach the gib face when the cutterhead axis is slewed (12) and hence the slewed head has a greater effective knife extension with corresponding decrease in power demand. On the other hand, the knives in the cutterhead used for Test Fox already had a liberal extension beyond the gib face (0.344 inches). Fig. 17 indicates that further knife extension will not substantially decrease the cutterhead power requirement.

Both plots show a tendency to curve rather sharply to zero horsepower requirement as zero depth of cut is approached, thus altering the approximately linear relationship that exists between 1/16 inch depth of cut and 1/4 inch depth of cut.

D. Test George: This two-factor experiment was designed to test the interaction of the variables of depth of cut and direction of cutterhead rotation with relation to direction of feed. As discussed in connection with Figs. 2 and 3 of the previous article (4), there are two primary directions of cutterhead rotation with relation to the direction of feed. Up-milling applies to all of this test series except the one under consideration. In this test a brief comparison is drawn between the up-milling process and that process known as down-milling. Fig. 14 illustrates the geometry of down-milling.

An understanding of the kinematic relationships between up-milling and down-milling may be attained through a study of the formulae developed by Martellotti (7) (8). If these formulae are applied to a situation in which a jointed, 8-knife, 9-inch cutting-circle cutterhead revolving at 3450 RPM is taking a 1/8 inch deep cut at a feed speed of 300 FPM, the information in the table below is revealed:

In other words, down-milling results in a greater wave height on the finished surface, a shorter radius of knife trace curvature, a shorter length of knife engagement, and a thicker undeformed chip than does up-milling under similar circumstances. A large

	Distance between knife marks or feed per knife in inches	Wave height in inches	Instantaneous radius of curvature of knife path in inches	Length of knife engagement in inches	Average undeformed chip thickness in inches
Up-Milling	0.130	0.000441	4.83	1.100	0.0048
Down-Milling	0.130	0.000511	4.18	1.022	0.0060

wave height and a short radius of knife trace curvature are usually considered detrimental when evaluating the quality of a planed surface.

An 8-knife, 9.08 inch diameter cutting-circle cutterhead with a 30-degree rake angle was used in this test. A feed speed of 206 FPM was employed with depths of cut ranging from 1/64 to 1/4 inches.

Both up-milling and down-milling readings were taken serially from the same specimen as described on the test data sheet. The photographs employed in the discussion were not taken of the actual test specimen. They illustrate the principle involved rather than individual test readings, as has been the case previously.

The surfaces produced by both up- and down-milling under the conditions of the test were satisfactory at all depths of cut. The most striking difference to be observed was the elimination by down-milling of the moderate amount of chip marking present during the up-milling process. This is a reasonable result, as in down-milling the knife tips have a chance to wipe themselves clean of adhering chips and fiber bundles before they reach that short final section of engagement that defines the resulting surface. Further, in down-milling it is possible that each element of the resultant surface is not produced by direct contact of the knife tip with the surface, but rather is defined by the intersections of the planes of shear failures of the deforming chips.

By contrast, the initial fraction of an inch of knife engagement defines the resultant surface in up-milling. Therefore, if there is anything adhering to the knife tip it is sure to register as an indentation of the finished surface. Of course, it wave height or knife trace radius is used as a measuring stick of surface quality, then the down-milling process presents a surface inferior to up-milling for a given feed per knife.

Table 10 presents the horsepower requirements in tabular form. Fig. 15 gives the same information in chart form. From these data it is observed that the down-milling process as tested requires more cutterhead power than does up-milling.

Table 10.—NET HORSEPOWER REQUIREMENT FOR WOOD REMOVAL FROM 1" WIDE STOCK UNDER TEST GEORGE CONDITIONS*

Depth of Cut in Inches	Direction of Cutterhead Rotation with Relation to Direction of Feed: Conventional Up-Milling (Against Feed)	Down-Milling (With Feed)
1/64	0.34	0.41
1/32	0.53	0.65
3/64	0.88	1.06
1/16	1.12	1.45
1/8	1.39	1.86
1/4	2.32	----

*Refer to Table 9 for resume of factors.

It will be noted from a comparison of the two processes that there is a fundamental difference in the manner of knife approach. In up-milling the knife engages the work in nearly tangential relationship to the surface previously milled by the preceding knife, and therefore beginning chip thickness is minute. By contrast, the down-milling knife approaches the rough or unmachined surface at a distance equal to the feed per knife from the path generated by the previous knife, and after chip formation emerges in a nearly tangential fashion. It is apparent that the down-milling knife engages at a point of much greater chip thickness than does the up-milling knife.

An explanation for the higher cutterhead power demand of down-milling as compared to up-milling lies in the fact that average chip thickness is greater for down-milling than it is for up-milling, and due to the attitude of the knife at engagement, energy-saving advance splitting that is frequently characteristic of up-milling is not so likely to occur in the down-milling process.

It has been determined by Kivimaa (3) that in the range of rake angles most frequently used, i.e., plus 15 to plus 45 degrees, the cutterhead has a tendency to lift the work piece away from the bedplate when using a circular path type chip testing device. This approximates the situation with up-milling where holddown mechanisms are necessary to keep the work piece from lifting under action of the cutterhead. By contrast, in the down-milling process the work is held strongly against the bedplate due to

Table 9.—RESUME OF FACTORS APPLYING TO TEST GEORGE

Variable Factors:
- Direction of Cutterhead Rotation with Relation to Direction of Feed: (Conventional up-milling against feed and down-milling with feed)
- Depth of Cut in Inches: (1/64, 1/32, 1/16, 3/32, 1/8, and 1/4)

Fixed Factors:
- Specimen:
  - General Description: The test piece was a nine-foot-long dry 1 by 3 board
  - Species: Pseudotsuga taxifolia
  - Wood Type: Heart
  - Rings per Inch: 17 ±2
  - Width of Machined Surface: 0.785 ±0.002 inches
  - Angle of Annual Rings to Machined Surface: 30 ±4 degrees
  - Spiral Grain: None
  - Percent Moisture Content (based on O.D. weight): 8.9 ±0.3
  - Specific Gravity (based on O.D. weight and O.D. volume): 0.374 ±0.008
  - Inclination of Diagonal Grain to Direction of Feed: None
- Cutterhead:
  - Head Body: Jointer type, 8-knife
  - Gibs: Flat (i.e. not concave) chipbreaking surfaces at right angles to the knife face
  - Knives: 5/16-inch thick with corrugated back
  - Number of Knives: 8
  - Cutting Circle Diameter: 9.08 inches
  - Rake: 30 degrees
  - Clearance: 20 degrees
  - Knife Extension beyond Gib: 0.344 ±0.010 inches
  - Width of Joint: 0.007 ±0.001
  - Nominal RPM of Cutterhead: 3600
- Feed:
  - Speed: 206 ±3 FPM

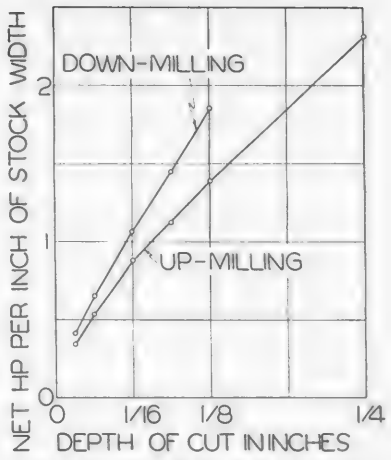

Fig. 15.—Net cutterhead horsepower requirement for wood removal under Test George conditions comparing conventional up-milling against feed to down-milling with feed.

Fig. 16.—Test George. (A) Down-milling; 1/4-inch depth of cut; 175 FPM feed speed. (B) Down-milling; 1/2-inch depth of cut; 175 FPM feed speed. (C) Up-milling; 1/4-inch depth of cut; 175 FPM feed speed. (D) Up-milling; 1/2-inch depth of cut; 175 FPM feed speed.

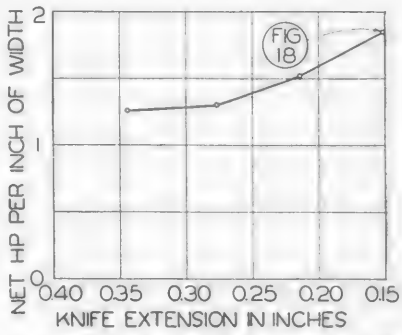

Fig. 17.—Net horsepower requirement for wood removal under Test How conditions comparing various distances of knife extension beyond gib face.

Fig. 18.—Test How. 8-knife, 8.70-inch cutting-circle cutterhead with knives extended 0.152 inch from gib face taking a 3/32-inch deep cut at a feed speed of 300 FPM.

the manner of knife engagement, as illustrated in Figs. 16A and 16B. While the foregoing force encountered in down-milling may be of some advantage, the accompanying horizonal force vector, which tends to bring together cutterhead and work piece at an uncontrolled rate, is a definite disadvantage in view of the continuous manner in which lumber is planed. In general, it is undesirable to operate a planer with the outfeed rolls firmly engaged because of the additional chip marking they cause, and for this reason it does not seem practical to attempt to use them or a similar device to retard and control the flow of lumber through a machine employing the down-milling process.

A further difficulty incidental to down-milling is observed in Fig. 16B, which indicates that chip collecting might be more difficult than under up-milling conditions as illustrated in Figs. 16C and 16D.

Martellotti (8) in his study of metal milling found that cutterhead spindle power was greater for down-milling than for up-milling under a given set of conditions, but that this power penalty was more than offset by a decrease in necessary feed power. In other words, when both spindle and feed power requirements were considered, down-milling required less power than up-milling.

Engelsson, Hvamb, and Thunell (2), in their studies of circular sawing techniques, reported that down-milling required 50 to 70 per cent more spindle power than did up-milling under their test conditions. Under the conditions of their tests, the decreased feed power required for down-milling was not sufficient to compensate for the increased spindle power. In other words, in this instance the total power required was greater for down-milling than it was for up-milling.

Other studies by Thunell (13) as well as research by Skoglund and Hvamb (11) discuss up- and down-milling as applied to circular sawing technique, but they are of such a nature that they do not permit direct comparison with this work.

The results reported herein are not inconsistent with the findings cited above.

E. Test How: This single factor experiment was designed to study the effect of varying the knife extension beyond the face of the gib. In order to have a definite surface from which to gauge the extension, gibs having a flat face at right angles to the knife face were selected. These gibs are illustrated in Fig. 18. While there is little doubt that gib shape has an important bearing on the relationship between horsepower requirement and knife extension, this test considers only the gib shape illustrated.

The increments of knife extension were determined by the distance between corrugations on the back of the 5/16-inch-thick knives. As the knives were reseated at each succeeding lesser extension, the cutting circle diameter was reduced by a corresponding amount. The effect on horsepower requirement of this reduction of cutting circle diameter was partially offset by an increase in joint width occasioned by rejointing following each reseating of the knives.

An 8-knife cutterhead, a feed speed of 300 FPM, and a depth of cut of 3/32 inches were selected as a representative median situation. Fig. 17 indicates that from a point of view of power consumption, this particular gib should utilize a knife extension of not less than 9/32 inches when operating under these conditions. A knife extension of 0.152 inches uses 46.8 per cent more power than a knife extension of 0.344 inches.

Fig. 18 permits visulization of the abrupt chip deformation caused by a smaller knife extension.

F. Test Ivy: This two-factor experiment was designed to study the interaction of the variables of width of joint and depth of cut. The tests were run serially on a single specimen as described in Table 13. The depths of cut ranged from 1/64 to 1/4 inch. An 8-knife, 9.08-inch diameter cutting-circle, 30 -degree rake angle cut-

Table 11.—RESUME OF FACTORS APPLYING TO TEST HOW

Variable Factor: Knife Extension in Inches beyond Face of Gib	Corresponding Cutting-Circle Diam. in Inches	Corresponding Width of Joint in Inches
0.344 ± 0.011	9.08	0.007 ± 0.001
0.277 ± 0.015	8.95	0.011 ± 0.002
0.214 ± 0.012	8.82	0.017 ± 0.006
0.152 ± 0.011	8.70	0.019 ± 0.008

Fixed Factors:
- Specimen:
  - General Description: The test piece was a 9-foot-long dry 1 by 3 board
  - Species: Pseudotsuga taxifolia
  - Wood Type: Heart
  - Rings per Inch: 17 ± 2
  - Width of Machined Surface: 0.785 ± 0.002
  - Angle of Annual Rings to Machined Surface: 30 ± 4 degrees
  - Spiral Grain: None
  - Percent Moisture Content (based on O.D. weight): 8.9 ± 0.3
  - Specific Gravity (based on O.D. weight and O.D. volume): 0.374 ± 0.008
  - Inclination of Diagonal Grain to Direction of Feed: None
- Cutterhead:
  - Head Body: Jointer type, 8-knife
  - Gibs: Flat (i.e. not concave) chipbreaking surfaces at right angles to the knife face.
  - Knives: 5/16-inch thick with corrugated back
  - Number of Knives: 8
  - Rake: 30 degrees
  - Clearance: 20 degrees
  - Nominal RPM of Cutterhead: 3600
- Feed:
  - Speed: 300 ± 1 FPM
  - Depth of Cut: 3/32 inch

Table 12.—NET HORSEPOWER REQUIREMENT FOR WOOD REMOVAL FROM 1" WIDE STOCK UNDER TEST HOW CONDITIONS*

Knife Extension Beyond Gib Face Inches	Cutting-Circle Diameter Inches	Net Horsepower
0.344	9.08	1.26
0.277	8.95	1.30
0.214	8.82	1.52
0.152	8.70	1.85

*Refer to Table 11 for resume of factors.

Table 13.—RESUME OF FACTORS APPLYING TO TEST IVY

Variable Factors:
- Width of Joint in Inches: (0.007 ± 0.001 and 0.040 ± 0.009
- Depth of Cut in Inches: (1/64, 1/32, 1/16, 3/32, 1/8, and 1/4)

Fixed Factors:
- Specimen:
  - General Description: The test piece was a nine-foot-long dry 1 by 3 board.
  - Species: Pseudotsuga taxifolia
  - Wood Type: Heart
  - Rings per Inch: 17 ± 2
  - Width of Machined Surface: 0.785 ± 0.002
  - Angle of Annual Rings to Machined Surface: 30 ± 4 degrees
  - Sprial Grain: None
  - Percent Moisture Content (based on O.D. weight): 8.9 ± 0.3
  - Specific Gravity (based on O.D. weight and O.D. volume): 0.374 ± 0.008
  - Inclination of Diagonal Grain to Direction of Feed: None
- Cutterhead:
  - Head Body: Jointer type, 8-knife
  - Gibs: Flat (i.e. not concave) chipbreaking surfaces at right angles to the knife face
  - Knives: 5/16-inch thick with corrugated back
  - Number of Knives: 8
  - Cutting-Circle Diameter: 9.08 inches
  - Rake: 30 degrees
  - Clearance: 20 degrees
  - Knife Extension beyond Gib: 0.344 ± 0.010 inches
  - Nominal RPM of Cutterhead: 3600
- Feed:
  - Speed: 206 ± 3 FPM

Table 14.—NET HORSEPOWER REQUIREMENT FOR WOOD REMOVAL FROM 1" WIDE STOCK UNDER TEST IVY CONDITIONS*

Depth of Cut in Inches	Width of Joint in Inches 0.007	0.04
1/64	0.34	0.47
1/32	0.53	0.71
1/16	0.88	1.01
3/32	1.12	1.30
1/8	1.39	1.58
1/4	2.32	..

*Refer to Table 13 for resume of factors.

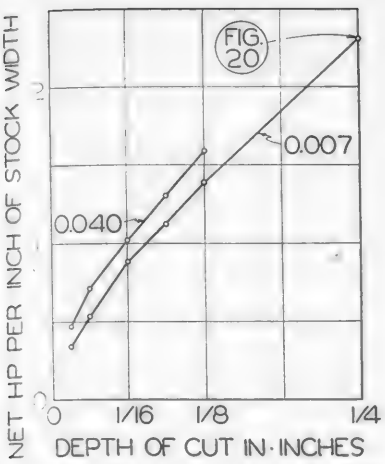

Fig. 19.—Net horsepower requirement for wood removal under Test Ivy conditions comparing 0.040-inch and 0.007-inch widths of joint.

terhead was employed with a feed speed of 206 FPM.

The horsepower readings were first taken for the 0.040-inch width of joint, after which the knives were heel ground and lightly rejointed to a joint width of 0.007 inches.

The surfaces produced were generally satisfactory, although considerable chip marking was evident with both widths of joint at all but the lightest cuts. Table 14 shows the net horsepower requirements. Fig. 19 is a plot of this same information. Considering depths of cut up to and including 1/8 inch, the cutterhead mounting knives with 0.040-inch width joint took 19.3 per cent more power than the same cutterhead mounted with knives having an 0.007-inch width of joint. Fig. 20 illustrates the cutterhead used. Knives with a wide joint require more power for the same reason that knives with exceedingly low clearance require more power, i.e., the heel interferes with the machined surface as the knife nears the end of its path. It will be observed from pictures presented that the clearance angle decreases and the rake angle increases from the nominal values as the knife moves toward emergence in the up-milling process. Therefore, the jointed surface of the knife, by the nature of its generation, is certain to interfere to some degree with the work piece.

It will be noted that the percentage of power penalty occasioned by the greater joint width tends to decrease as the depth of cut increases. The percentage of penalty ranges from a high of 38.2 per cent at 1/64-inch depth of cut to a low of 13.7 per cent at 1/8-inch depth of cut. The explanation may lie in the possibility of more advance splitting taking place at the larger depths of cut with correspondingly less interference between knife heel and work piece.

Fig. 20.—Test Ivy. 8-knife, 9.08-inch cutting-circle cutterhead with knives jointed to a heel width of 0.007 inch taking a 1/4-inch deep cut at a feed speed of 206 FPM.

Petter (10) reports that a heavily jointed cutterhead requires approximately 75 per cent more power than a lightly jointed cutterhead. In the absence of details on the widths of joints involved in the test cited, the information seems in general agreement with the results reported here.

Conclusions

The various factors tested to determine their relationship to net cutterhead horsepower requirement have been discussed as they occurred in the individual tests of the series being reported. A re-inspection of the information permits some conclusions to be drawn. The comments are grouped according to the factor involved.

Cutterhead Factors

A. Diameter of Cutting-Circle (Test Able): For any given combination of factors, an increase in cutting-circle diameter will increase the cutterhead power requirement. Under the test conditions, it was found in a summation of all factors that a 9.02-inch diameter cutting-circle cutterhead requires 7.35 per cent more power than a 7.63-inch diameter cutting-circle head. This difference in power demand is more pronounced with green stock, on which the large cutterhead requires 10.8 per cent more power than the smaller head. On dry stock, the large head requires 3.37 per cent more power than the small head.

B. Knife Extension Beyond Face of Gib (Test How): Up to a certain critical value, the knife extension beyond the face of the gib is inversely related to the horsepower requirement of the cutterhead. The critical value of knife extension depends on the conformation of the knife and gib combination. In the simplified test situation where the gib face is perpendicular to a 30-degree rake angle knife face, it was found that the knife extension should be at least 9/32 inch beyond the face of the gib. Under the conditions of the experiment, a 5/32-inch extension requires approximately 40 per cent more power than does a 9/32 inch extension.

C. Width of Joint (Test Ivy): The width of joint exerts a very pronounced influence on the cutterhead power demand. The magnitude of the effect is inversely related to the depth of cut. These experiments indicate that, under the test conditions on dry stock, a joint width of 0.040 inches requires 38.2 per cent more power than does a joint width of 0.007 inches when operating at a 1/64 inch depth of cut. At a 1/8 inch depth of cut, the cutterhead with the wider joint took 13.7 per cent more power.

Feed Factors

A. Angle between Rotational Axis of Cutterhead and Direction of Feed (Test Fox): A slight cutterhead horsepower advantage was noted when the rotational axis of the cutterhead was slewed to make a 70-degree angle with the direction of feed as compared with the conventional 90-degree angle. Although the cutterhead employed for the tests had adequate knife extension as previously defined, it is possible that the greater effective knife extension obtained when the spindle axis was slewed from its normal position accounts for the horsepower saving recorded.

B. Direction of Cutterhead Rotation with Relation to Direction of Feed (Test George): Under the test conditions using an 8-knife cutterhead in conjunction with a 206 FPM rate of feed on dry stock, down-milling takes an average of 25.4 per cent more cutterhead power than does up-milling in the conventional fashion. The percentage of penalty is related to the depth of cut involved, ranging from 20.6 per cent at a 1/64-inch depth of cut to 33.8 per cent at a 1/8-inch depth of cut.

Workpiece Factors

A. Specific Gravity (Test Easy): In general the net cutterhead horsepower requirement increases with an increase in specific gravity of the wood being machined. This relationship exists at varying depths of cut. Under the conditions of the test, the percentage increase in net cutterhead horsepower demand is sensitive to the feed speed involved. At 150 FPM an increase in specific gravity from 0.35 to 0.70 (oven dry weight, oven dry volume basis) results in an average of 60-per cent increase in power demand, while at 307 FPM the per cent increase is 70 per cent. The test results show such a spread of horsepower demand values for specimens with equal or nearly equal specific gravity values that a valid generalization is difficult to make.

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Discussion

Milton H. Mater (Mater Engineering Co.): Did you calculate the horsepower required to remove one cubic inch of wood under varying circumstances?

Mr. Koch: The ordinates of the horsepower curves we have been discussing represent net horsepower consumption per inch of stock width. Inasmuch as the depth of cut and the feed rate is known for each test situation, the rate of wood removal (in cubic inches per minute) can be easily calculated. Corresponding horsepower consumption can be read directly from the horsepower curves (or from the tables of data relating to each test).

Mr. Mater: Did you try climb milling with different rake and clearance angles to determine the effect on horsepower requirements?

Mr. Koch: No, I didn't; however, the results of the rather extensive up-milling test (test Charlie) involving the variables of rake angle, clearance angle, depth of cut and per cent moisture content were reported in Part I of this paper (published in the August 1955 FOREST PRODUCTS JOURNAL). A similar experiment could be executed for climb-milling.

R. V. Reynolds (Kennametal, Inc.): Is testing equipment available for general testing?

Mr. Koch: Perhaps half the equipment required is immediately available and the other half could be readily obtained with the cooperation of industry.

W. J. Tomford (James E. Star., Co.): Were there any differences other than power observed in slewing or changing knife angle?

Mr. Koch: All of the surfaces produced in this experiment (Test Fox) were satisfactory, regardless of whether they were produced by slewed or conventional cutterhead orientation. It was observed, however, that on lumber that was prone to chip-marking the diagonal orientation of the chip marks (as produced by the slewed head) made them more obvious to the eye. The effect of the slewed head on torn grain needs further exploration. In passing it might be observed that the slewed head is not a new idea. As early as 1884 such a machine was produced in this country by the S. A. Woods Company.

Effect of Tractor Logging upon Hardwood Stands[1]

DAVID E. HERRICK

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and

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A study was made of the amount and kind of damage to residual stands resulting from the use of 12 different combinations of skidding equipment and two skidding methods. Results indicate that skidding injury occurs chiefly on sapling-sized trees, bunching with sulky or arch results in least amount of disturbed area and smallest number of injured trees per unit of volume removed, and there is no appreciable difference between the influence of log-length and tree-length logging upon residual stocking.

IN ANY WOODLAND MANAGEMENT system involving selective cutting, some of the trees left in the residual stand will be injured or destroyed by the skidding operation. Foresters recognize and accept this—but as the intensity of the forest management they practice increases, so does their concern about damage due to logging. Prudent forest managers are now seeking answers to such questions as: "Just how serious is logging injury; does it actually reduce the ability of an area to produce the desired crop; if so, how can it be minimized; and how can the effect of unavoidable damage be anticipated and accounted for in management plans?"

A series of logging studies designed to help answer these, and similar questions, is being conducted on the Kaskaskia Experimental Forest in southern Illinois. The study reported here was designed to compare the amount and kind of damage to the residual stand resulting from the use of 12 different combinations of skidding equipment and two skidding methods.[2] Some other reports on the general subject of logging injury are listed in the Bibliography.

Scope of Study

This study included log-length and tree-length skidding of mixed hardwoods by diesel-powered, crawler-type tractors equipped with various conventional logging attachments. In the log-length phase of the study, each of three tractors (32-, 43-, and 66-horsepower units)[3] was used to bunch 72 loads of logs—18 loads by each of four different attachments (butt hook, winch, winch and pan, and winch and rubber-tired sulky or arch)[4]. Only the 43-horsepower tractor with sulky and the 66-horsepower tractor with arch were used to bunch and skid the tree-length loads. All three tractors were equipped with straight dozer blades throughout the study.

The tests were conducted in conjunction with a stand improvement cut in uneven-aged, upland hardwood timber located in the Ozark Uplift region of southerin Illinois. These timber stands consisted of 20 to 40 sawtimber-sized and 35 to 45 pole-sized trees per acre, and a spotty but generally heavy understory of saplings. Most of the cut was made up of trees that had been bypassed due to their large size, inaccessible location, defective condition, or species when the area was logged for tie and charcoal timber at about the turn of the century. Consequently, the majority were overmature, large-crowned, and partly unsound.

The terrain of the area logged was rather rugged, consisting chiefly of short, steep ridges separated by narrow ravines. Generally, these ravines cannot be negotiated with tractors, so for tractor operations the topography divides the area into units that require uphill skidding.

Logging Procedure

It is generally acknowledged that the felling crew can do much to influence skidding injury. The amount of area disturbed and the number of trees struck are both reduced when the trees harvested are felled in a direction that allows easy access to the stems and requires a minimum of maneuvering to align the load with the haul route. This is especially true in tree-length logging; but due to the prevalence of large crowns and defective butts among the trees harvested in this study, directional felling was not attempted. Although most trees were wedged a few degrees right or left to avoid a "hang up" or injury to a "leave" tree, all were dropped in the general direction of their lean.

Following natural terrain features, the log-length study area was divided into nine blocks that averaged about 5 acres in size. These blocks were organized into three groups having similar stocking conditions and one of the three tractors was randomly assigned to each group. Within a block, the designated tractor was used to bunch and skid 24 turns of logs—six with each of the four different attachments. The tree-length area was set up in a similar manner.

Each experimental block included in the study was partly bordered by a permanent all-weather road. All log

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[1] Presented at Session X, Logging and Milling, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] This study was conducted in cooperation with: Caterpillar Tractor Co., Peoria, Ill.; Hyster Co., Peoria, Ill.; Southern Illinois University, Carbondale; U. S. Forest Products Laboratory, Madison, Wis.; Fabick Machinery Co., Marion, Ill.; and Taylor Machine Works, Louisville, Miss.

The Authors: D. E. Herrick, graduate of Iowa State College, was associated with H. and R. Lumber Co., Osceola, Iowa, and Iowa State College before joining Forest Service. He was at the U. S. Forest Products Laboratory from 1951–53, when he was transferred to the Carbondale Center as Project Leader in the Utilization Section.

G. H. Deitschman holds B.S. degree from U. of Minnesota, M.F. from Pennsylvania State College. He has been employed by the Central States Forest Experiment Station since 1948, served as Regeneration Project Leader at the Carbondale Center before transferring to the Ames Center this year as acting Research Center Leader.

[3] Caterpillar D-2, D-4, and D-6.

[4] A Hyster rubber-tired sulky was used with the D-2 and D-4 tractors. A Hyster rubber-tired arch was used with the D-6.

Table 1.—ORIGINAL STOCKING AND VOLUME HARVESTED BY STUDY AREAS

Test block group*	Tractor size	Trees per acre: Saplings (1.6″–4.5″) Number	Trees per acre: Poles (4.6″–10.5″) Number	Trees per acre: Sawtimber (10.6″ +) Number	Basal area per acre Square feet	Sawtimber volume per acre: Original Board-feet	Sawtimber volume per acre: Cut Board-feet
LOG-LENGTH AREA							
A	32-hp.	132	43	37	68.8	6,550	3,240
B	43-hp.	163	33	37	75.2	6,250	2,985
C	66-hp.	158	34	36	68.3	6,770	3,665
TREE-LENGTH AREA							
D	43-hp. and 66-hp.	158	41	18	62.9	3,915	1,615

*Each group consisted of three test blocks.

decks were located next to this road. A skidroad was cut down the main ridge line of each block, at about a right angle to the permanent road. All loads (both log- and tree-length) were bunched by the assigned equipment combination, skidded up a "make-as-you-go" skid trail to a skidroad, and then along this road to a deck. Tractor "skinners" did not sacrifice production to minimize injury to standing trees but they did attempt to avoid unnecessary damage. For example, when given a choice they struck a sapling instead of a pole, a poorly formed tree instead of a well-formed one, and a hickory instead of a yellow-poplar.

Evaluation of Injury

In order to make the results most meaningful and usable, damage was evaluated by an estimate of: (1) severity of injury to individual trees, and (2) the influence of this injury upon over-all stocking of the residual stand. This procedure was prompted by the recognition of four principles:

1. Some trees struck in logging are damaged only slightly or not at all, while others are destroyed completely.
2. The more trees present on a given logging chance, the greater will be the number exposed to injury during the logging operation.
3. Injury to a larger or a better tree is more serious than injury to a smaller or poorer one.
4. Severe injury to a tree in a densely stocked stand is less important than similar injury in a lightly stocked stand.

Estimates of tree injury caused by the various equipment combinations were based upon examinations of trees within and adjacent to bunching areas and skid trails. As felling injury was not influenced by differences in skidding equipment, trees damaged in felling were not individually inspected. Decking areas and skidroads were excluded from consideration because they are regarded as areas permanently taken out of timber production. Four degrees of injury were recognized, as shown below.

These classes are admittedly arbitrary and subjective. They are based on limited knowledge concerning the chances of tree recovery, with no attempt to evaluate precise losses from cull development and reduced growth rates.

A 20 per cent cruise using 1/10-acre plots was used to determine sawtimber volume and size class distribution on the study area prior to logging. Residual stocking was measured on 0.002-acre plots totaling 10 per cent of the area. In the latter, a plot was considered to be stocked if it contained at least one living tree exceeding 1.5 inches in diameter that had not been severely injured.

All 0.002-acre plots were classified as representing: (1) undisturbed area, (2) bunching area, (3) trail area, or (4) felling area. If at least half of the ground covered by a plot had not been disturbed by the logging operation, it was classified as "undisturbed area." Conversely, if half the ground covered had been affected (as evidenced by skinned trees, disturbed litter and soil, or position of the down tops) by bunching, by a skid trail, or by felling, the plot was classified as "disturbed-bunching," "disturbed-trial," or disturbed-felling." This classification was used to estimate the percentage of the logged area affected by the four logging activities, and the influence of each activity upon subsequent stocking.

Results

Stand Description: Composition of the stands logged during the study was found to be similar except for number and volume of sawtimber-sized trees (Table 1). All blocks supported approximately the same number of stems per acre but the tree-length area had fewer large trees—and hence less volume—than the log-length area. Prior to logging, the log-length stand averaged about 71 square feet of basal area and 6,500 board-feet of volume per acre. The tree-length stand had 63 square feet of basal area and 3,900

Injury class	*Characteristics*
A. No apparent injury (no effect on tree development expected).	1. Tree struck but bark not broken. 2. No rootspring.
B. Light injury (excellent chance of remaining, merchantable).	1. Sapwood exposed but smooth, with wound on 1 face only and 1 foot or less in height. 2. No rootspring.
C. Moderate injury (considered to have at least 50–50 chance of becoming, or remaining, merchantable).	1. Sapwood exposed, smooth or lacerated, with wound on 2 faces or on 1 exceeding 1 foot in height. 2. May have slight rootspring.
D. Severe injury (little possibility of becoming, or remaining, merchantable).	1. Exposed sapwood, smooth or lacerated, on more than 2 faces; or any wound exposing heartwood. 2. May have serious rootspring.

Table 2.—TREE INJURY RESULTING FROM LOG-LENGTH AND TREE-LENGTH BUNCHING

Skidding method*	Size of area Acres	Sawtimber volume per acre: Original Bd.-ft.	Sawtimber volume per acre: Cut B.d-ft.	Stems per acre exposed to injury: Saplings (1.6″–4.5″) Number	Stems per acre exposed to injury: Poles and sawtimber (4.6″ +) Number	Area disturbed in bunching 1,000 bd.-ft. Sq. ft.	Trees injured per 1,000 sq. ft. of bunching area: Saplings (1.6″–4.5″) Number	Trees injured per 1,000 sq. ft. of bunching area: Poles and sawtimber (4.6″ +) Number	Poles and sawtimber-sized trees injured per acre Number
Log-length	8.9	6,520	3,225	160	56	1,120	3.4	0.5	1.8
Tree-length	17.4	3,915	1,615	158	52	2,170	4.7	0.7	2.4

*Equipment used: 43-horsepower tractor with sulky and 66-horsepower tractor with arch.

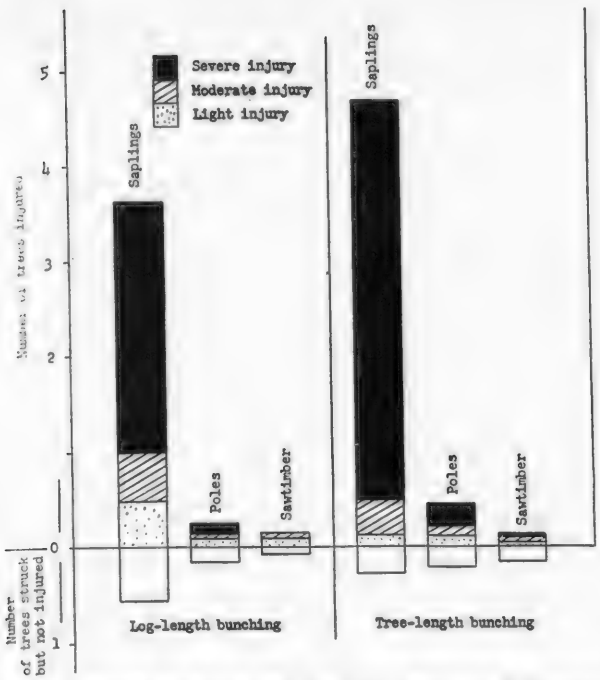

Fig. 1.—Number of trees struck per 1000 square feet of bunching area and severity of injury, in bunching log-length vs. tree-length loads.

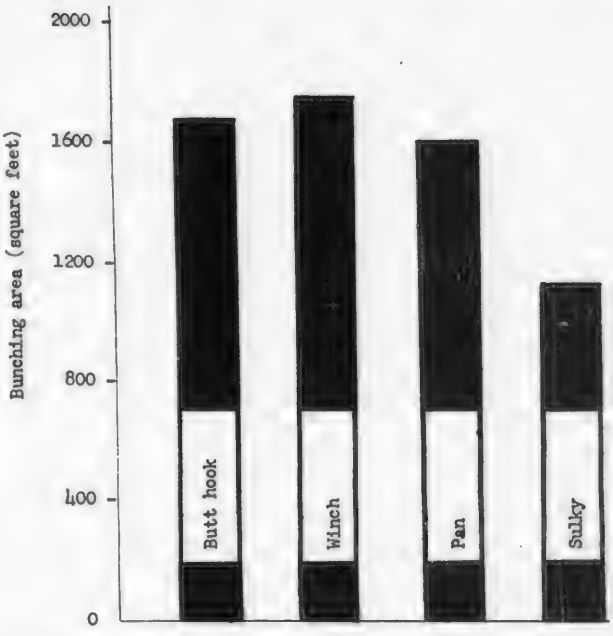

Fig. 2.—Area disturbed in bunching 1000 board feet of logs.

board-feet of volume. Approximately 3,300 board-feet were cut from the log-length stand, and 1,600 board-feet from the tree-length.

Injury in Bunching Areas: The number of trees injured per unit of bunching area did not differ significantly[5] among the various tractor sizes and equipment combinations tested, but bunching log-lengths resulted in less frequent and less severe injury than did bunching tree-lengths (Fig. 1). On the log-length area, an average of 4.8 trees exceeding 1.5 inches in diameter were struck *per 1,000 square* feet of bunching area and 2.7 of these were seriously injured; on the tree-length area about 5.9 trees were struck and 4.5 seriously injured. In both instances, about 85 per cent of the trees struck—and approximately 95 per cent of those severely damaged—were saplings.

A better comparison of log-length vs. tree-length bunching can be made by studying the frequency and severity of injury in areas where the same equipment combinations were used (Table 2). In log-length bunching, using the 43- or 66-horsepower tractor with sulky or arch, about 4 trees exceeding 1.5 inches in diameter were injured per 1,000 square feet of bunching area. Only 1 out of 8 of these was a pole- or sawtimber-sized tree. As a result, for each acre of the logging chance, less than two trees exceeding 4.5 inches in diameter were injured. When the same equipment was used to bunch tree-lengths, about 5 trees more than 1.5 inches in diameter were injured per 1,000 square feet of bunching area. As in the log-length area, only 1 out of 8 of those injured exceeded 4.5 inches in diameter and the number injured per acre logged was small—only 2.4 trees of pole-size or larger.

On the log-length area, regardless of tractor size, the area disturbed per 1,000 board feet of logs bunched was significantly and consistently smaller when the sulky or arch was used (Fig. 2). The area covered in bunching 1,000 board feet with the butt-hook, winch, and winch and pan averaged 1,700 square feet. By contrast, the area covered in assembling the same volume with the sulky or arch averaged 1,140 square feet. This difference was reflected in a lower frequency of injury *per 1,000 board feet* caused by sulky bunching—an average of about 5 trees injured compared to a combined average of nearly 7 for the other attachments. On an over-all stand basis, therefore, the smaller bunching area per unit volume resulting from use of the sulky or arch reduced total injury well below that caused by other attachments.

Injury in and along Skid Trails: Most trees within the borders of the skid trails were completely destroyed or severely damaged. The width of the trails and the number of trees injured increased with tractor size (Fig. 3). Trails averaged about 9 feet wide for the 32-horsepower tractor, 10 feet for the 43-horsepower tractor, and 11 feet for the 66-horsepower tractor. Because the tractor operators could usually follow natural openings in the stands, few trees struck exceeded 1.5 inches in diameter.

Injury to trees bordering the skid trails was caused primarily by striking with the dozer blade (Fig. 4). On the log-length area, an average of 2.9 trail-bordering trees were injured (3.5 were struck) for each 100 feet of skidding distance (Fig. 5). About two-thirds of those struck were moderately or severely injured, but as in the bunching areas, most were small; more than 80 per cent of those injured were saplings. Differences among the numbers injured by the various equipment combinations and load sizes were not statistically significant. However, there was a tendency for the larger tractors to strike larger trees. The basal area of the trees struck increased with tractor size from 0.19 square feet per 100 lineal feet of skid trail for the 32-horsepower tractor, to 0.76 square feet for the 66-horsepower tractor. Most of this increase consisted of negligible or very minor injury to the larger trees and evidently was due to the wider path made by the bigger tractors.

Reliable data on tree injury in or along the skid trails of the tree-length area were not available but general observations indicate that results similar to those found in the log-length area could be expected. In both areas the dozer blades were responsible for practically all of the injury to bordering trees.

Although the dozer blades damaged some residual trees (especially those bordering skid trails), in many ways

[5] "Significance" is used here, and subsequently, in the statistical sense. For a significant difference, the probability is 19 to 1 that a real difference exists.

Fig. 3.—Log-length skidding with a 32-horsepower tractor, the smallest tested. Injury in and along skid trails was least for this tractor size. Ground skidding did not cause significantly greater injury than pan or sulky skidding.

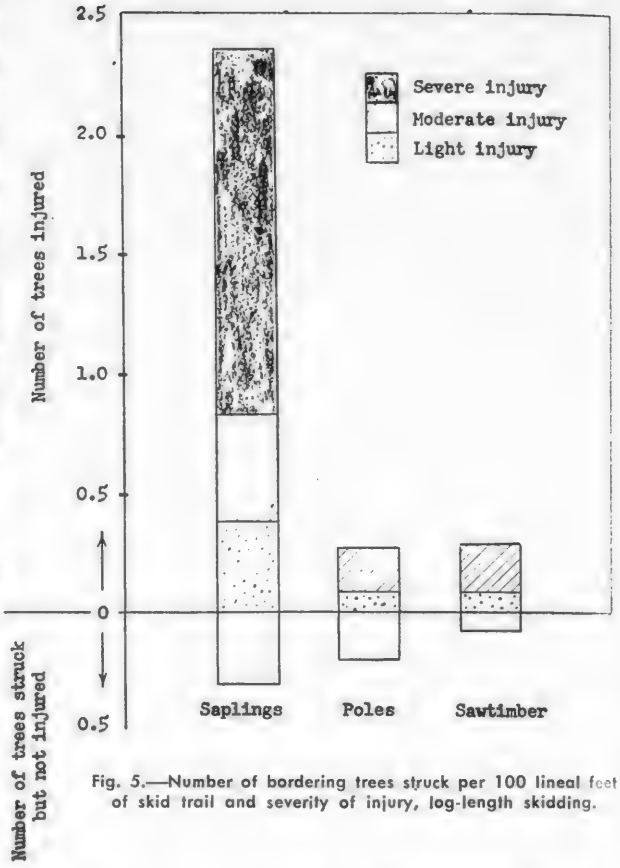

Fig. 5.—Number of bordering trees struck per 100 lineal feet of skid trail and severity of injury, log-length skidding.

they helped reduce over-all tree injury by facilitating the logging operation. For example:

1. All logs were "cold-decked." Using the blades to stack the logs at the deck minimized the area denuded for this purpose (Fig. 6).

2. Use of the blades to move tops and logs aided in the bunching operation. Moving a top a few feet often allowed access to logs that otherwise would have required a trip around the top, or an approach from another direction; usually, either would have involved more injury to the residual stand.

3. The blades were often used to advantage during the empty run to close small gullies and prepare footing for the loaded run.

Fig. 4.—Skidding damage. Injury to trees bordering skid trails was caused principally by the dozer blade. The scar shown would be described as moderate injury.

4. The weight of the blades improved traction on steep slopes and provided an anchor for winching.

5. As a result of better footing and improved traction, use of the blades allowed the operators to be more selective in choosing their haul routes. Thus trail length could be held to a minimum and injury to preferred trees often avoided.

6. The blades helped protect the tractor operator.

Effect of Injury upon Stocking: Approximately one-third of the log-length area and a little more than one-sixth of the tree-length area was disturbed, and thus subjected to tree damage by logging (Table 3). This difference is probably due chiefly to the difference in intensity of cut on the two areas. As the cut per acre on the tree-length area was only half as heavy as that on the log-length (7 trees as compared to 14), it is not surprising that the portion of the tree-length area disturbed by felling was found to be only about half as great. Similarly, the smaller number of trees harvested per acre meant fewer loads —and thus fewer trails—per acre on the tree-length area. The number (and area) of trails on the tree-length area was further reduced by the larger loads hauled. When considering all equipment combinations, tree-length loads averaged one-third larger than log-length loads.

Presumably because of the difference in intensity of cut, only 1,120 square feet were disturbed per each 1,000 board feet of log-lengths bunched, while an average of 2,170 square feet were disturbed in bunching a similar volume of tree-lengths. But the lighter cut on the tree-length area required that proportionately more acres be logged to produce the volume needed. Consequently, the part of the total area disturbed by bunching was about the same on the tree-length area as it was on log-length—8 per cent vs. 9 per cent.

Skidroads made up another 6 per cent of the area disturbed on each study area but, unlike the trails, these roads will be retained as permanent access routes; consequently, they are no longer regarded as producing space.

Considering those 0.002-acre sample

Table 3.—AREA DISTURBED BY LOG-LENGTH AND TREE-LENGTH LOGGING WITH CRAWLER-TYPE TRACTORS

Logging activity	Per cent of area disturbed	
	Log-length area	Tree-length area
Felling	14	8
Bunching	9	8
Skidding	8	2
Total	31	18

Fig. 6.—The bulldozer blade proved helpful in many logging activities. Above, it is being used to stack logs at the deck. The sulky behind the tractor and the pan in the left foreground were two of the skidding attachments tested.

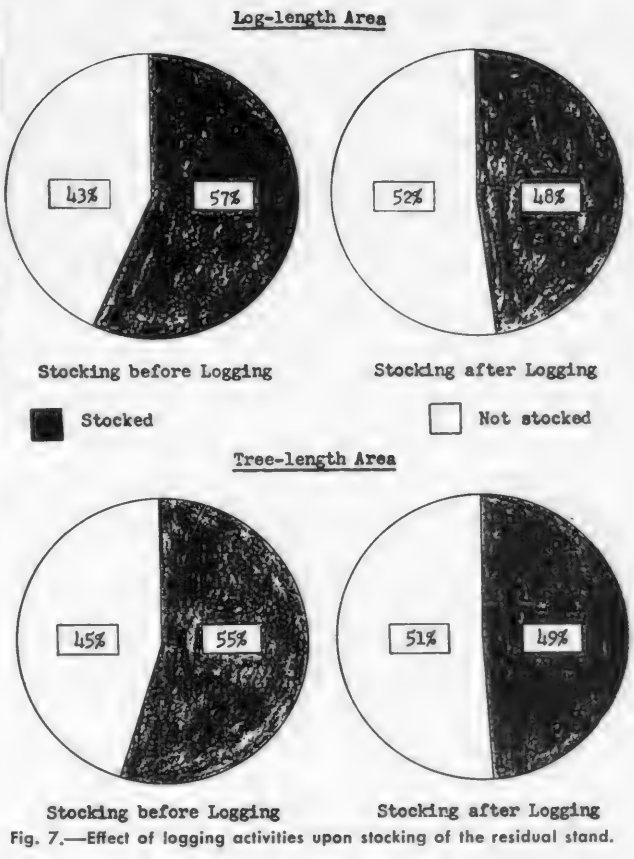

Fig. 7.—Effect of logging activities upon stocking of the residual stand.

plots that fell in undisturbed parts of the stand as being representative of the whole study area before logging, the original stocking on the log-length area was 57 per cent and that on the tree-length area 55 per cent. By comparison, stocking after logging was 48 and 49 per cent, respectively, or a reduction (not including those trees harvested) of 9 per cent on the log-length area and 6 per cent on the tree-length area (Fig. 7). Within the felling, bunching, and skidding areas themselves, the percentage of stocked plots decreased to about one-half of that found on undisturbed plots.

Summary and Conclusions

The extent and severity of injury to residual trees as a result of selective logging in uneven-aged upland hardwoods was recently investigated in southern Illinois. This study was designed to (a) test the difference in bunching and skidding injury caused by each of 12 combinations of crawler-type tractors and skidding attachments, (b) compare the damage caused by log-length and tree-length skidding, and (c) evaluate the effect of such injury upon over-all stocking. Within the limitations of stand structure, level of stocking, skill of the logging crew, equipment combinations used, and other conditions of the tests, the following conclusions can be drawn from the results obtained:

1. In log-length bunching, the combination of tractor size and attachment used has no important effect upon either the number of trees struck *per unit of bunching area (1,000 square feet)* or the degree of injury to those that are struck.

2. Regardless of tractor size, bunching log-lengths with a sulky or arch will result in the least amount of disturbed area and fewer injured trees *per unit of volume (1,000 board-feet)* removed.

When directional felling is not practiced, tree-length loads can be expected to strike a greater number of trees *per unit of bunching area,* and injure them more severely than log-length loads.

4. The larger the tractor, the wider the skid trails and, thus, the greater the damage for a *given length (100 lineal feet) of trail.*

5. Tractor size has no important effect upon total number or severity of injury to trees bordering the skid trails. The larger tractors strike more large trees but cause only minor damage to them.

6. When reasonable precautions are taken to minimize injury, less than 10 per cent of the residual trees should be damaged as a result of the logging operation.

7. Unavoidable logging injury is concentrated chiefly on sapling-sized trees; few pole- and sawtimber-sized trees are seriously injured.

8. Log-length and tree length logging differ very little in their influence upon the over-all level of stocking of the residual stand.

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Discussion

Clarence Richen (Crown Zellerbach Paper Co., Portland, Ore.): The opportunity to partially cut or thin young forests to increase their wood yield and to improve their quality is growing throughout the nation. Foresters know what trees and species to select and to remove to get the benefit of increased yield and improved quality of young stands. The silvicultural selection of trees in a good economic marketing area is not a deterrent to successful management of the stand.

The primary problem is working on a selective or light thinning basis without damaging the trees remaining for future growth. Thinning young stands in which 10 to 20 per cent of the trees are cut involves falling, bucking, and skidding to the roadside. Skidding can be done by horses, by overhead cable system, or by tractors.

Tractors, however, are used more than horses and cable systems because

of availability, versatility, and ease of operation. It is fitting, therefore, that cooperative studies, such as the one by Herrick and Deitschman, be undertaken to see what can be done to economically skid logs in the young forest with a minimum damage to the trees which are left for future growth.

Conditions in the Douglas-fir region are not comparable to the hardwood stands described by the authors. I am surprised that tractor size has shown no important effect on the amount or degree of damage in the stand. In our coniferous stands, 40 to 70 years of age containing 200 to 400 trees to the acre, we believe tractors should be limited in size to D–4 or smaller. We would not be satisfied with damage to residual stands of 10 per cent which the authors say is obtainable "with reasonable precautions". 2 to 3 per cent damage in skidding would be maximum in our thinning operations.

The authors and the others cooperating in the study should be commended for their constructive practical approach to a major problem in obtaining successful forest management of young trees.

R. J. Kowal (Southeastern Forest Experiment Station): Observations by Kirby Lumber Corp. and the Southern Forest Experiment Station indicate that track-type tractors injure tree roots and compact the soil to the extent that trees may become weakened and susceptible to insect attack. We feel this is likely and that rubber-tired tractors would not cause such injury or compaction. Do you have any comparisons between track-type tractors and rubber-tired tractors as far as soil compaction is concerned?

Mr. Herrick: No. With the exception of rootspring, we dealt only with injury to the tree bole or to exposed roots.

Power Requirements for Sawing Redwood Cants with Seven-Foot Diameter Bandmill[1]

MILTON H. MATER

Mater Engineering, Corvallis, Oregon

Reports results of tests conducted in a modern redwood sawmill of approximately 50,000 board feet per shift capacity. Analyzes curves of amperes drawn by the bandmill vs. time in the cut during the sawing cycle and effect of knots in the cants on amperage requirements. Calculations of power required per cubic inch of wood removed in sawing redwood cants at different speeds are shown and the resulting curves analyzed. Conclusions are drawn as to relationship of sawing power requirements to cutting speeds.

Purpose of Tests

TESTS WERE MADE in August 1955 at Big Lagoon, California, in Sawmill No. 3 of the Hammond Lumber Company, to investigate the possibility of developing an automatic sawing control device. This device would control the speed of sawing logs and cants so that each cut would be made at optimum speed; that is, the maximum speed possible under existing conditions of resistance to sawing due to variations in hardness of wood, defects and knots in the wood, saw sharpness, height of log or cant sawn thru, and all other variables encountered in the usual supply of timber to a sawmill.

At the present time, the speed of sawing is controlled by the sawyer, who judges the optimum speed by the sound of the saw cutting through the wood and by personal judgement based on experience. This control is erratic and has been found in other tests conducted by the author to vary by as much as 22 per cent under normal condition. The variation is almost always in the direction of lost production because, when too high a speed is used in sawing, mismanufactured lumber results.

To investigate the practicability of developing a sawing speed control system, we proceeded as follows:

a) Set up a series of criteria for an acceptable end product; that is, determined allowable variations in dimension and surface finish of the rough board so that it could be dried and planed to make a saleable finished piece of lumber.

b) Investigated various indicators of sawing speed to determine which one could best be developed as a controller. Three possible indicators were investigated: saw blade deflection, band mill strain arm movement, and electric current requirements of the bandmill during the sawing cycle.

This paper reports on the data obtained regarding the last item mentioned above, electric current requirements of the bandmill during the sawing cycle.

When it was decided to investigate the current requirements of the bandmill during sawing, it was found that no data was available which would tie the current requirement to the end product criteria. Since the investigators felt that this method offered the greatest chance for developing an automatic sawing control device, it was decided to gather all the necessary data which would be required to develop such a device during this one preliminary test. A large part of this data consisted of curves showing the amperage requirements of the bandmill motor at different sawing speeds. The area under the curves represented the power required to saw the redwood cants.

The Hammond Lumber Company turned over control of the sawmill operation at their Mill No. 3 to our firm for the weekend of August 27–28, 1955. The sawmill crew operated the mill, conducting the test according to the procedure we required. The General Electric Company's San Francisco office supplied the necessary instruments and a team of three skilled instrumentation and application engineers to gather the data. The author was in charge of the tests, with an assistant who made the necessary auxiliary investigations and aided in controlling the tests.

Two sources of power are required for the sawing operation:

a) The power required to move the log carriage past the saw. This is a variable, depending on the weight of the log or cant and its resistance to sawing. This resistance varies greatly, depending on the height of the cant

[1] Presented by title only at Session X, Logging and Milling, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: M. H. Mater is managing owner of Mater Machine Works, sawmill machinery manufacturers, and Mater Engineering, consulting engineers. A licensed mechanical engineer, he has written more than 35 papers on sawmill modernization and related subjects. Mater is Chairman of the FPRS Sawmilling Division.

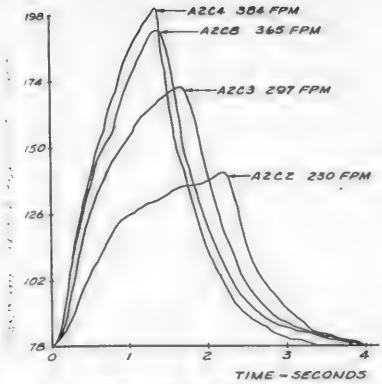

Fig. 1.—Band mill motor current vs. time. Cant 30 inches high, 8 feet, 2 inches long; 465 volts.

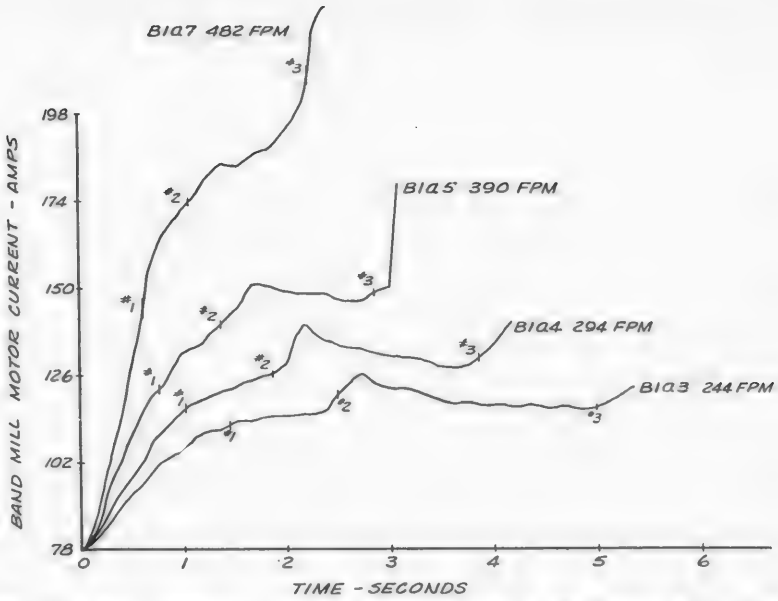

Fig. 2.—Band mill motor current vs. time. Cant 12½ inches high, 20 feet long; 465 volts.

and many indeterminate factors, such as hardness (which varies in different parts of the cant); the presence of knots or defects, which cannot be detected from the surface of the cant; and other conditions such as wetness or dryness of the wood, brittleness, the presence of foreign matter, etc. The source of this power in this sawmill was a G. E. Amplidyne controlled M.G. set.

b) The power required to cut thru the cant at the optimum speed. This power is supplied to the bandmill by an electric motor which drives the lower bandwheel thru 'V' belts.

Test Set-up and Procedure

Machinery and Instruments: The sawmill machinery involved in these tests were:

(a) Sumner Iron Works 7-foot double cut bandmill.

(b) General Electric 150 HP Amplidyne controlled carriage feed.

(c) Mater Machine Works 48-inch opening automatic carriage.

Test Procedures, Calibrations, and Conduct of Tests: The tests were run in two parts:

a) Entry speed tests: To determine the effect of making the saw enter the cut at various speeds on 8-foot long cants of three different heights, 12, 20, and 30 inches.

b) Sawing speed tests: To determine the effect of sawing a 20-foot long cant at different speeds. Heights of cants were 12, 20, and 30 inches.

Results of Tests

Power Requirements at Different Speeds: The power required to saw redwood cants at different speeds was determined from analysis of the following information:

a) Curves of Bandmill Motor Ampere Requirements vs. Sawing Time (Fig. 1). All of the curves lead to the conclusion: *The Higher the Speed of Sawing, the Greater the Peak Amperage Required.*

b) The effect of knots on the bandmill power requirements at different speeds. This showed up clearly in curves obtained by the recording instruments. Fig. 2 shows the effect of sawing thru knots at different speeds.

Two major conclusions can be drawn from the analysis of this data:[2]

1. The peak amperage required by the bandmill motor rises when the speed of sawing becomes greater.

2. When a knot area is approached by the saw, more power is required from the bandmill motor if the speed of sawing is to remain constant.

Bandmill Power Requirements: An analysis of the power requirements of the bandmill during the sawing cycle indicates that the power requirement curve is made up of two distinct parts (Fig. 3). Within the initial four feet on the curves is the saw entry portion, where the inertia of the bandwheels is used to provide power to saw the cant; the remainder of the cant receives power for sawing from the motor only.

This analysis leads to the concept of a work balance; that is, the work added to the system should equal the

[2] A complete analysis of the effect of knots on power requirements is found in the original "Mater Engineering Report ME 29–4" to the Hammond Lumber Company.

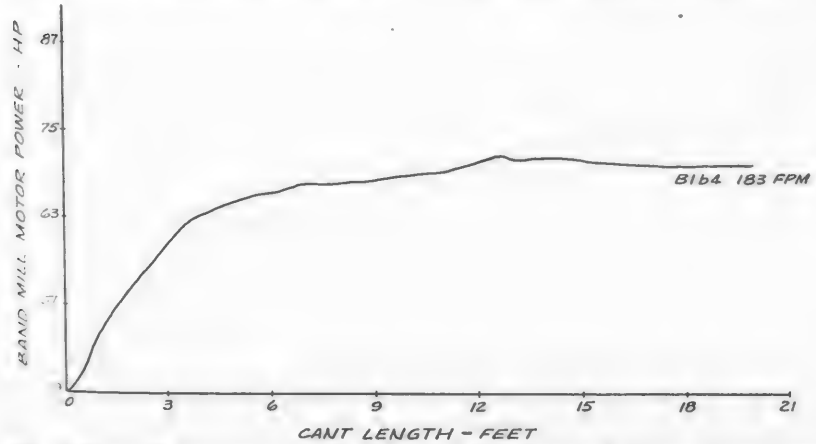

Fig. 3.—Band mill motor power vs. cant length. Cant 20¾ inches high, 20 feet 2 inches long.

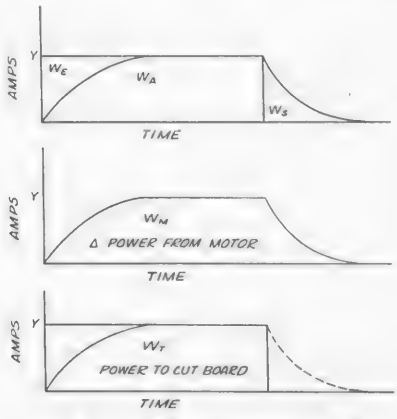

Fig. 4.—Energy requirements in the sawing cycle.

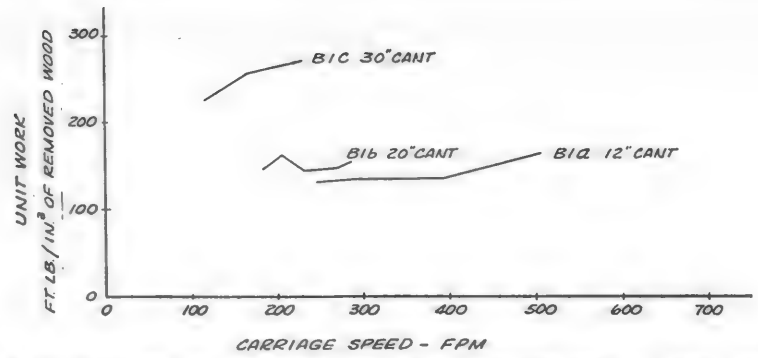

Fig. 5.—Work per cubic inch of wood removed vs. carriage speed for various cants. Note: Cubic inches of wood is based on width of saw tooth plus 0.03 inches clearance.

work taken out. This forms an equation as follows:

$W_E + W_M = W_T + W_S$ (See Fig. 4)

where W_E = Work supplied for sawing from the band mill inertia

W_M = Work supplied by the motor

W_T = Work required to saw thru the log

W_S = Work required to bring the bandmill up to no load speed

The work required to saw a board can then be expressed as

$$W_T = (W_E + W_M) - W_S$$

The work supplied to the saw by the inertia effect of the bandmill, W_E, was found to be roughly equivalent to the work required to speed the bandmill up to its no load speed after sawing, W_S. Therefore the equation becomes:

$$W_T = W_M$$

The above equation shows that the work done in sawing is equal to the total work done by the bandmill motor.

Since we now had the power requirements to saw a board, it became a simple matter to calculate the average amount of power required to remove a cubic inch of wood at various speeds. This equals 98.3 foot lbs/cu. inch.

A curve of work per cubic inch vs. speed was plotted and the results are shown in Fig. 5. The 12-inch cant and 30-inch cant show a rise in the power required to remove a cubic inch of wood with increasing speeds. The 20-inch cant is not as clear a picture, but this is probably due to the nature of the particular cant.

As a corollary to the above, a curve of equilibrium power vs carriage speed was plotted (Fig. 6). This shows quite clearly that the higher the speed, the greater the power requirements are. It also shows that the increased power requirements are less with a smaller cant as the power rises.

Conclusions

The tests described above are a beginning in a fascinating study of the cutting action of a saw through wood. While the work we did on this particular subject was only part of a larger project, still physical proofs were arrived at which confirmed, in most cases, the deductions of experienced men in the industry. The following conclusions were drawn:

1. The higher the speed of sawing, the greater the peak amperage required by the bandmill motor.

2. When an area containing a knot or wood of a greater hardness than the rest of the cant is reached, more power is required from the bandmill motor if the speed is to remain constant.

3. Approximately 13 horsepower is required to keep a 7-foot bandmill of the particular type used here at a constant speed of 397 RPM under no sawing load conditions.

4. The work done in sawing a cant is equal to the total work done by the bandwheel motor during the sawing cycle and just after the cut is completed in bringing the motor up to speed.

5. The power required to saw a board from a redwood cant 30 inches high and 8 feet long at 297 feet per minute is 66,500 foot-pounds, under the test conditions described above.

6. The average power required to remove one cubic inch of wood under these same conditions is 98.3 foot-pounds.

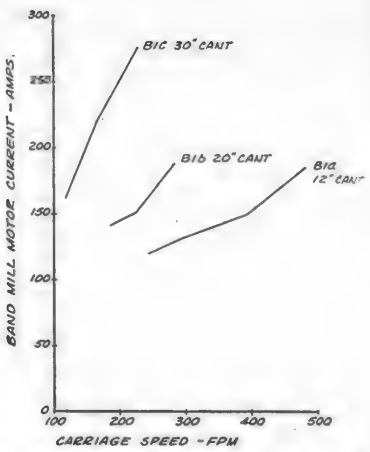

Fig. 6.—Power to cut cants (in amps) vs. carriage speed for various cants.

All of the participants in the tests feel that this is only a good beginning for a series of tests on sawing power requirements which has long been needed in the industry.

Acknowledgements

The tests reported on in this paper were undertaken in behalf of the Hammond Lumber Company of Samoa, California. This redwood lumber manufacturing company has retained our engineering firm to conduct a Research and Development program in their No. 3 Sawmill at Big Lagoon, California. The results reported herewith are the property of the Hammond Lumber Company and it is with their permission that this paper is presented.

The General Electric Company cooperated in making these tests in order to obtain the data, which is of great value to their wood industries division. They are also interested in the development of certain control equipment which is touched on briefly in this paper.

W. L. Antonson, then of the Motor Engineering staff, acted as the author's assistant in conducting the tests, calculating the results, and drawing the curves. Mr. Antonson is now Research and Development Engineer at Hammond Lumber Co.

The Shrinkage Intersection Point—Its Significance and the Method of Its Determination

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Shrinkage intersection points were determined for six species and the values obtained by different methods compared. The possibility of estimating the intersection point from the basic density and volumetric shrinkage was studied and a correlation coefficient of 0.76 was found to exist between unit volumetric shrinkage and basic density for 131 species. A correlation was observed between the intersection point and the equilibrium moisture content at any given relative humidity for five species.

THE GENERAL MANNER in which the transverse shrinkage of wood depends on moisture content has been established by a large number of tests (3, 9, 17)[1] and a typical curve is shown in Fig. 1.

Shrinkage generally commences at a moisture content somewhat greater than 30 per cent, and once a moisture content of 25 to 15 per cent has been reached, the shrinkage increases approximately linearly with a decrease in moisture content to less than 5 per cent moisture content. At still lower moisture contents, the shrinkage-moisture content curve exhibits a slight curvature concave towards the origin. The shrinkage intersection point is defined as the moisture content at which the extended linear portion of the shrinkage-moisture content curve intersects the line of zero shrinkage (17).

Similarly, most mechanical properties of wood are practically independent of moisture content while the wood is green but below a certain moisture content the logarithm of the measure of the property is approximately linearly dependent on moisture content. The intersection point for the particular property is defined as the moisture content at which the extended linear portion of the graph intersects the line for the constant green value.

It has been claimed by Stamm (13) and Wilson (17) that the value of the intersection point is approximately the same for all properties of any one species. Stamm (13) has claimed that an equivalent moisture content also exists for the electrical resistance-moisture content relation. He found that below a certain moisture content the logarithm of the electrical resistance is linearly dependent on the moisture content, and that the departure from linearity occurs at a moisture content approximately equal to the intersection point obtained by other means.

As it is evident that the moisture held inside the cell wall will have a greater effect on the properties of the wood than that held in the cell cavity, many workers have attempted to identify the intersection point with the so-called "fiber saturation point", i.e., the moisture content at which the cell cavities are empty but the cell walls are completely saturated. However, Barkas (2) has shown that there is no sharp change in the slope of the moisture content-relative humidity isotherm at humidities approaching saturation, and thus that there is no definite moisture content corresponding to a fiber saturation point. He has also pointed out that certain variations in the intersection point do exist, depending on the property for which it is determined.

This impossibility of attaining a precise fiber saturation point invalidates any identification of the intersection point with the fiber saturation point, but it is no doubt more than fortuitous that the intersection points for all properties of any one species appear to fall within a range of 4 or 5 per cent moisture content, and that this moisture content usually approximates the equilibrium moisture content within 1 per cent of saturation.

The practical importance of the intersection point is in the estimation of the variation of any property with moisture content. If the intersection point is known, the value of the property at any moisture content in the region of linear dependence may be calculated from the value of the property in the green state and at one moisture content in the linear region.

The determination of the intersection points corresponding to many of the mechanical properties may be inaccurate for, since the tests are destructive, imperfect matching of test specimens introduces scatter in the relationship. Difficulty is also experienced in determining the exact point of tangency to the straight line in the estimation of the intersection point corresponding to the electrical resistance.

The shrinkage intersection point, on the other hand, may be relatively simply determined using a single test specimen. If the intersection points are approximately the same for all properties of any one species, the separate determination of the value of each is unnecessary, and the value of the shrinkage intersection point may be used for all properties. In this paper, various methods of estimating the shrinkage intersection point are investigated, and recommendations are made as to the most satisfactory procedure.

Direct Determination of the Shrinkage Intersection Point from Shrinkage-Moisture Content Curves

General: The shrinkage intersection point may be determined most directly by extending the straight-line portion of a complete shrinkage-moisture content curve obtained from the shrinkages at a large number of moisture contents during drying from the green state. This method is tedious, however, and a simpler method providing reasonably accurate results is desirable.

Attempts have been made to estimate the intersection point from the results of routine shrinkage tests carried out according to the standard procedures (1, 5) which specify that measurements should be made in the green, air-dry, and oven-dry states. The intersection point may be calculated from these results as follows:

$$\text{Intersection point (per cent)} = \frac{\text{air-dry moisture content (\%)}}{\text{shrinkage from air-dry to oven-dry (\%)} \times \text{shrinkage from green to oven-dry (\%)}}$$

[1] Numbers in parentheses refer to literature cited.

Author: Kathleen E. Kelsey received B. Sc. and M. Sc. degrees from the University of Melbourne. Since 1949 she has been studying wood-water relation as a Research Officer with the Division of Forest Products, C.S.I.R.O., Melbourne.

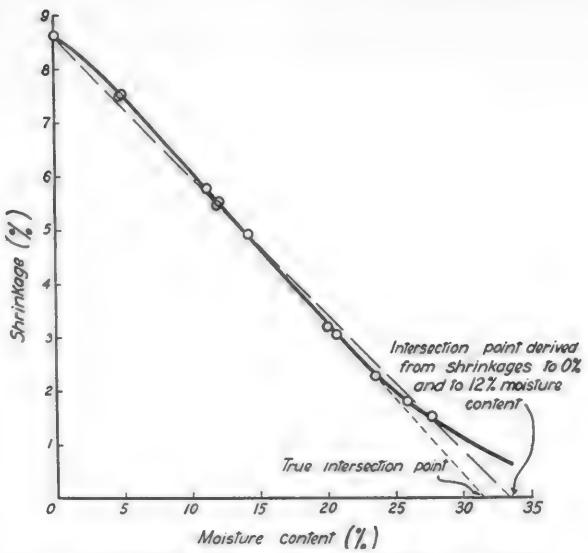
Shrinkage (%)
Moisture content (%)
Intersection point derived from shrinkages to 0% and to 12% moisture content
True intersection point

Fig. 1.—Tangential shrinkage of yellow birch as a function of moisture content [from results of Wilson (17)].

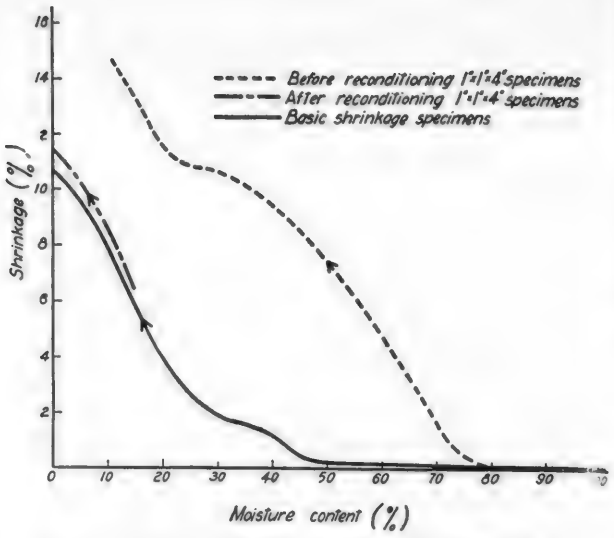

Fig. 2.—Tangential shrinkage of *Eucalyptus obliqua* as a function of moisture content.

However, some unusually high values of the intersection point obtained in this way have drawn attention to the departure from linearity in the shrinkage-moisture content relationship at very low moisture contents. It is apparent from Fig. 1 that intersection points calculated in this way will be higher than those obtained from the complete curve by an amount depending on this curvature.

The error due to the curvature at low moisture contents may be eliminated and the number of measurements involved kept to a minimum, by making an additional measurement at about 5 per cent moisture content and calculating the intersection point from the shrinkage to the air-dry state and to this moisture content. It is necessary to establish, however, that errors are not introduced by slight departures from linearity even in this portion of the relationship or due to the smaller difference in moisture content over which the calculation is made.

The present paper describes an investigation of the shrinkage intersection points obtained by each of these methods. In addition, it gives an account of a study of the effect of specimen size on the estimated intersection point.

Preparation of Specimens: The six species used in this study were chosen from available green material to cover as large a range of density, shrinkage, and intersection point values as practicable. They included both collapsing and non-collapsing hardwoods and one softwood. A list of the species used and the number of trees tested is given in Table 1.

In order to investigate the effect of specimen size and the accompanying effects of drying stresses and collapse, two groups of specimens were tested—those used in the routine shrinkage determinations by Kelsey and Kingston (10) and basic shrinkage specimens as described by Greenhill (7). These were respectively 1 in. × 1 in. in cross section and 4 in. along the grain, and 0.5 in. × 0.5 in. in cross section and about 0.04 in. along the grain. Greenhill showed that if specimens are cut sufficiently short along the grain, collapse does not occur, and that if the edge length is sufficiently small, drying stresses are reduced to a minimum.

Two 1 in. × 1 in. × 4 in. longitudinal specimens were cut from each tree, both having faces truly radial and tangential. One basic shrinkage specimen approximately 0.04 in. along the grain was cut from material end-matched to each of these specimens. The top surface of the small specimen was planed prior to cutting to facilitate subsequent measurement, and its edges were afterwards trimmed to give a truly radially and tangentially cut specimen of the required size.

Experimental Procedure: *1 in. × 1 in. × 4 in. specimens*—The specimens were weighed in the green state and measured in the three principal directions. Weighings were made to 0.02 g. and length measurements to 0.001 in. The volumes were determined to 0.1 c.c. gravimetrically by displacement of water. The specimens were allowed to air-dry slowly, and measurements were made at approximately 10 per cent moisture content steps to 30 per cent moisture content and then at 5 or 6 per cent moisture content steps to 12 per cent moisture content. When the required moisture content had been reached at each stage during drying, the specimens were stored in a sealed container for at least one week before measurements were made in order to ensure that moisture gradients in the specimen were at a minimum.

After the specimens had been measured at 12 per cent moisture content, they were "reconditioned" to remove collapse by immersion in an atmosphere of steam at 100° C. for 2 hours (8). Subsequently measurements were made at about 12, 9, and 5 per cent moisture content, and the specimens were finally oven-dried at 105° C. until constant weight was attained. The oven-dry specimens were weighed and measured linearly immediately after removal from the oven, and were then covered with a thin coating of paraffin wax and when cold measured both in length and volume.

Basic Shrinkage Specimens—A certain amount of drying was unavoidable during the cutting of the small specimens but before any measurements were made the specimens were re-wetted to a moisture content which was in most cases higher than that of corresponding larger specimens. Shrinkage measurements were made at moisture content steps during drying similar to those used for the larger specimens but the small specimens were not reconditioned until drying had been completed.

The transverse dimensions were measured to 0.0001 in. with a measuring microscope, the specimens being sealed between two microscope slides while the measurements were in progress. The specimens were weighed to 0.01 per cent before and after measurement to check on any change in moisture content that may have occurred. Longitudinal and volumetric measurements were omitted in this case.

Table 1.—MEAN INTERSECTION POINTS OBTAINED BY VARIOUS METHODS

Species	No. of Trees Tested	Specimen Size (in.)	Reconditioning Treatment	Method*	Tan. Int. Point (%)	Rad. Int. Point (%)	Vol. Int. Point (%)	Tan. + Rad / 2 Int. Point (%)
Eucalyptus elatum (Roxb.) Wall	3	1 × 1 × 4	after rec.	complete curve	27.1	24.2	26.5	25.6
		1 × 1 × 4	after rec.	green to 12 and 5% M.C.	26.9	23.8	26.5	25.4
		1 × 1 × 4	after rec.	green to 12 and 0% M.C.	27.8	25.2	----	----
		1 × 1 × 4	before rec.	complete curve	27.0	26.2	27.3	26.6
		basic shrinkage	after rec.	complete curve	27.0	23.6	----	25.3
Eucalyptus microcorys F.v.M.	1	1 × 1 × 4	after rec.	complete curve	26.2	24.8	25.0	25.5
		1 × 1 × 4	after rec.	green to 12 and 5% M.C.	26.2	24.6	25.1	25.4
		1 × 1 × 4	after rec.	green to 12 and 0% M.C.	27.4	25.7	----	----
		1 × 1 × 4	before rec.	complete curve	26.5	24.8	26.5	25.6
		basic shrinkage	after rec.	complete curve	27.0	23.6	----	25.3
Eucalyptus obliqua L'Herit.	3	1 × 1 × 4	after rec.	complete curve	32.2	27.7	30.1	30.0
		1 × 1 × 4	after rec.	green to 12 and 5% M.C.	32.7	27.2	30.7	30.0
		1 × 1 × 4	after rec.	green to 12 and 0% M.C.	34.6	28.8	----	----
		1 × 1 × 4	before rec.	complete curve	43.1	34.0	41.6	38.5
		basic shrinkage	after rec.	complete curve	32.2	25.6	----	28.9
Eucalyptus paniculata Sm.	1	1 × 1 × 4	after rec.	complete curve	23.5	21.0	22.2	22.2
		1 × 1 × 4	after rec.	green to 12 and 5% M.C.	23.5	21.2	22.2	22.4
		1 × 1 × 4	after rec.	green to 12 and 0% M.C.	24.6	22.2	----	----
		1 × 1 × 4	before rec.	complete curve	23.5	22.2	24.2	22.9
		basic shrinkage	after rec.	complete curve	26.2	21.8	----	24.0
Nothofagus cunninghamii Oerst.	6	1 × 1 × 4	after rec.	complete curve	26.7	23.4	26.4	25.0
		1 × 1 × 4	after rec.	green to 12 and 5% M.C.	27.0	23.4	25.5	25.2
		1 × 1 × 4	after rec.	green to 12 and 0% M.C.	28.4	24.8	----	----
		1 × 1 × 4	before rec.	complete curve	30.9	25.5	30.5	28.2
		basic shrinkage	after rec.	complete curve	29.3	23.4	----	26.3
Tristania conferta R. Br.	1	1 × 1 × 4	after rec.	complete curve	28.8	26.0	27.0	27.4
		1 × 1 × 4	after rec.	green to 12 and 5% M.C.	28.2	25.4	27.2	26.8
		1 × 1 × 4	after rec.	green to 12 and 0% M.C.	29.8	26.8	----	----
		1 × 1 × 4	before rec.	complete curve	38.0	30.5	39.8	34.2
		basic shrinkage	after rec.	complete curve	29.2	25.4	----	27.3

*"Complete curve" in this column refers to the estimation of the intersection point by extension of the linear portion of the shrinkage–moisture content relation to zero shrinkage.

After drying, the specimens were allowed to regain an approximate air-dry moisture content before reconditioning in steam for ½ hour, precautions being taken to avoid condensation on the specimens during the steaming treatment. They were then air-dried and re-measured to ascertain whether any collapse had occurred.

Results: *Comparison of Intersection Points Obtained by Various Methods*—Tangential, radial and volumetric shrinkages were calculated for each specimen and plotted as a function of the moisture content, and the corresponding intersection points were determined by extending the linear portion of the graph. For the 1 in. × 1 in. × 4 in, specimens, these intersection points were obtained both before and after the reconditioning treatment for the removal of collapse. Intersection points were also calculated from the shrinkages of the larger specimens from 12 per cent to 5 per cent moisture content and to the oven-dry state, the dimensions of the cold specimens being used in the calculation of the shrinkage to the oven-dry state. A summary of the intersection points obtained by all these methods is given in Table 1.

It may be seen that in the absence of collapse (i.e., after the reconditioning treatment), the mean intersection point obtained from the extended straight line portions of the curves for the 1 in. × 1 in. × 4 in. specimens is not very different from that for the basic shrinkage specimens, although the latter does tend to be slightly greater than the former in the tangential direction and slightly less in the radial direction.

Values of the intersection point calculated from the shrinkage from green to 12 and to 5 per cent moisture content for the larger specimens do not appear to be significantly different from the values obtained from the shrinkage-moisture content curves for these specimens, so that a very good approximation to the intersection point may be obtained if measurements are made at 12 and 5 per cent moisture content only. However, values calculated between 12 per cent moisture content and oven-dry are definitely greater than the true values for the present species, the difference varying between 1 and 2 per cent moisture content.

In all cases the tangential intersection point was greater than the radial, the difference between these two intersection points being greater for the basic shrinkage specimens than for the 1 in. × 1 in. × 4 in. specimens. However, the mean of the radial and tangential values was not significantly different from the volumetric intersection point obtained from the shrinkage curves of the larger specimens.

The fact that such a small difference was observed between the intersection points obtained with specimens of two different sizes indicates that the shrinkage intersection point is a characteristic property of the species, whatever its physical significance may be. Only when collapse occurred (see shrinkage values of Table 2) was the intersection point markedly different for the two types of specimen and in such cases the difference was greatly reduced after reconditioning, as may be seen from Table 1.

The present results suggest that the marked dependence of the shrinkage intersection point on drying temperature as observed by Stevens (15) is caused by variations in the effect of drying stresses and collapse and draw attention to the need for using, in the estimation of the intersection point, only values of the shrinkage obtained after reconditioning. This is demonstrated by the shrinkage-moisture content curves of Fig. 2, which were obtained with badly collapsing specimens of *Eucalyptus obliqua*. The intersection point when estimated from the shrinkage before reconditioning is of the order of 50 per cent; when estimated after reconditioning it is about 30 per cent.

Comparison of Shrinkages Obtained by Various Methods—The basic density[2] determined on the larger specimens and the tangential and radial shrinkages obtained by the various methods are given in Table 2. The present results confirm the earlier findings of Greenhill (7), that in the absence of collapse the basic shrinkage specimens usually shrink to a greater extent than the larger specimens, the difference being more marked in the tangential direction. This difference is doubtless a reflection of the reduced drying stresses in the small specimens.

[2] Basic density is defined as the ratio of the oven-dry weight to the green volume.

It is of interest to note that the recovery of the basic shrinkage specimens on reconditioning was slight, confirming that their length along the grain must have been small enough to preclude collapse, and that drying stresses were at a minimum.

The present tests also allow a comparison to be made between the volumetric shrinkage obtained as a result of the direct measurement of volumes and that calculated from the three linear shrinkages. Direct determinations are specified by the British Standards Institution (5) and the American Society for Testing Materials (1) at 12 per cent moisture content and in the oven-dry state.

A comparison of the observed and calculated volumetric shrinkages over a range of moisture contents has been made in Table 3. This indicates that there is a tendency for the observed value to be greater than the calculated at all moisture contents. For the shrinkage to the oven-dry state, the results confirm those reported previously by Kelsey and Kingston (10), that the thermal expansion of the hot oven-dry specimens introduces errors into the calculated volumetric shrinkage, as the difference between the observed and calculated volumetric shrinkages is less when the cold linear dimensions are used in the calculations.

At the other moisture contents, the difference between the observed and calculated shrinkages is most pronounced with the coniferous species used, probably because the greater lumen diameter allows a greater penetration of the displacement liquid into the dry wood. However, whatever the reason for the difference, it is hardly large enough to justify the inclusion in the standard tests of a separate volumetric shrinkage determination additional to the linear shrinkage determinations.

The tests demonstrate clearly that shrinkage commences at moisture contents well above the intersection point. Even with small basic shrinkage specimens where collapse and drying stresses are negligible, in some cases appreciable shrinkage was observed at moisture contents over 10 per cent above the intersection point, as may be seen from Table 4. For species which collapse appreciably (see shrinkage values given in Table 2) the shrinkage-moisture content relation is very different at the higher moisture contents for the two types of specimen; in some cases shrinkages occurs at moisture contents up to 30 per cent above the intersection point. Fig. 2 shows an extreme example of this behavior.

Table 2.—VALUES OF SHRINKAGE AND DENSITY FOR SIX SPECIES TESTED

Species	Basic Density (g/cc)	Shrinkage from Green to 12% Moisture Content (%) — Tangential: 1 in. × 1 in. × 4 in. Specimens Before Rec.	Tangential: 1 in. × 1 in. × 4 in. Specimens After Rec.	Tangential: Basic Shrinkage Specimens Before Rec.	Radial: 1 in. × 1 in. × 4 in. Specimens Before Rec.	Radial: 1 in. × 1 in. × 4 in. Specimens After Rec.	Radial: Basic Shrinkage Specimens Before Rec.
Dacrydium elatum	0.472	4.53	4.41	4.92	2.04	2.12	2.14
Eucalyptus microcorys	0.800	5.90	5.35	5.98	3.85	3.52	3.75
Eucalyptus obliqua	0.566	10.88	7.42	7.79	5.32	4.14	3.98
Eucalyptus paniculata	0.967	5.90	5.40	7.32	2.92	2.70	3.52
Nothofagus cunninghamii	0.577	6.54	4.85	6.25	2.42	2.16	2.31
Tristania conferta	0.748	8.22	6.05	6.35	4.16	3.65	3.50

Table 3.—DIFFERENCE BETWEEN OBSERVED AND CALCULATED VOLUMETRIC SHRINKAGES AT VARIOUS MOISTURE CONTENTS

Species	Observed—Calculated % Volumetric Shrinkage from Green to a Moisture Content of: 20% Before Recond.	12% Before Recond.	12% After Recond.	5% After Recond.	Oven-Dry (Hot) After Recond.	Oven-Dry (Cold) After Recond.
Dacrydium elatum	+0.46	+0.84	+0.69	+0.93	+0.62	+0.38
Eucalyptus microcorys	+0.22	−0.15	−0.08	+0.10	+0.50	+0.02
Eucalyptus obliqua	+0.24	+0.05	+0.24	+0.35	+0.41	+0.08
Eucalyptus paniculata	−0.06	−0.07	−0.19	+0.02	+0.56	+0.16
Nothofagus cunninghamii	+0.20	+0.20	+0.40	+0.46	+0.45	+0.19
Tristania conferta	+0.48	+0.09	+0.09	+0.20	+0.48	+0.19

Table 4.—MOISTURE CONTENT AT WHICH APPRECIABLE SHRINKAGE WAS FIRST OBSERVED ON DRYING FROM GREEN STATE

Species	1 in. × 1 in. × 4 in. Specimens: Max. Green Moisture Content (%)	% M. C. at Which Shrinkage Exceeds: 0.2% Tan.	0.2% Rad.	0.4% Vol.	Basic Shrinkage Specimens: Max. Green Moisture Content (%)	% M. C. at Which Shrinkage Exceeds: 0.2% Tan.	0.2% Rad.
Dacrydium elatum	39	29	27	30	86	32	30
Eucalyptus microcorys	44	33	30	34	71	30	26
Eucalyptus obliqua	72	64	59	64	107	42	32
Eucalyptus paniculata	32	28	27	30	40	40	28
Nothofagus cunninghamii	59	45	37	47	120	42	31
Tristania conferta	51	50	46	52	67	48	38

Estimation of Intersection Points from Volumetric Shrinkages and Basic Density

Newlin and Wilson (12) found that for 177 American species whose average intersection point was about 29 per cent, the volumetric shrinkage to the oven-dry state was related to the basic density as follows:

volumetric shrinkage (per cent) = 28 × basic density (g/cc)

Stamm (14) considers that this proportionality between total volumetric shrinkage and basic density indicates that the intersection point gives an indication of the amount of moisture held in the cell wall. He suggested that the removal of all moisture from the cell wall is accompanied by shrinkage equal to the volume of the water removed (the density of water being 1 g/cc), and that the change in volume of the cell cavity is zero. He further suggested that the disparity of 1 per cent or so between the intersection point and the proportionality factor may be a reflection of the curvature in the shrinkage-moisture content relation at the lowest moisture contents, and is associated with the so-called "sorption compression".

On the other hand, Greenhill (9) did not find that the correlation between volumetric shrinkage and air-dry density was at all marked for Australian species, but he did not investigate whether the wider scatter was due to a wider variation in the intersection points of the Australian species.

Wangaard (16) found that for 48 tropical species, the volumetric shrinkage was considerably less than that calculated from the basic density using the relation for American woods. For the species of higher densities, the volumetric shrinkage was only about three-fifths that indicated by this relation. He suggested that this may be due to a lower "fiber saturation point" for tropical species but no measurements were available to confirm this suggestion.

If it could be established that these departures from the relation found by Newlin and Wilson (12) for American species are due to variations in the intersection point, it would be possible to estimate the intersection point from the total volumetric shrinkage and the basic density.

If the volumetric shrinkage from the green to the oven-dry state, S_v, is expressed as a percentage of the green

dimensions, and the basic density, ρ, is expressed in g/cc, the relationship obtained by Newlin and Wilson may be written

$$S_v \approx m_i \rho \qquad 1$$

where m_i is the per cent moisture content corresponding to the intersection point for these species. This relation has been given by Stamm (14). Such a method of estimating the intersection point would be particularly convenient because of the few measurements required. Equation *1* has been used by Krpan (11) to estimate the "fiber saturation points" of four European species from their volumetric shrinkages and basic densities. He obtained values which agreed reasonably well with the intersection points obtained from mechanical tests.

If the slight curvature in the shrinkage-moisture content relationship at low moisture contents is neglected, it is apparent that $\frac{S_v}{m_i}$ is approximately equal to the unit volumetric shrinkage, s_v, i.e., the shrinkage per per cent moisture content change in the linear region of the relationship, so that it follows from equation *1* that

$$S_v \approx \rho \qquad 2$$

That is, the unit volumetric shrinkage may be expected to be numerically approximately equal to the basic density when expressed in appropriate units.

Data are available from recent routine shrinkage and density tests on 131 Australian and Pacific Island species by means of which the correlation between unit volumetric shrinkage and basic density may be investigated. The unit shrinkage values were determined from the shrinkage between 12 and 5 per cent moisture content after reconditioning, and should therefore be a reliable estimate.

Fig. 3 shows the observed variation in the unit volumetric shrinkage with basic density for the species tested. Statistical analysis showed that the regression coefficient in the relation between unit shrinkage and basic density (in g/cc) was not unity, but that

$$s_v = 0.465\rho + 0.238$$

The correlation coefficient was 0.76, i.e., only 57 per cent of the variation in unit shrinkage was accounted for by the variation in basic density. No significant difference was observed between the correlation for the Australian and the Pacific Island species. The number of trees and specimens tested varied widely for the different species. Where a large number of trees were tested, the deviations from the regression line appear to be reduced, as may be seen from Fig. 3.

The departure of the regression coefficient from unity is probably largely due to a change in the size of the cell lumina during drying, so that the change in the external volume of the wood is not equal to the volume of the water removed. For European species studied by Beiser (4) and Clarke (6), little change in the size of the cell cavity was observed during drying but no such measurements have been reported for Australian species. Constancy of size of the cell lumen in every case is hardly to be expected, as the restraining sheath is on the outside of the cell wall, and does not surround the lumen.

Values of the intersection point calculated using equation *1* will therefore be in error due to: (a) the non-linearity of the shrinkage-moisture content relation at low moisture contents, and (b) deviation of the regression coefficient between unit volumetric shrinkage and basic density (in g/cc) from unity.

The error due to the non-linearity at low moisture contents may be eliminated, and the other error reduced by using the volumetric shrinkage from green to 12 per cent moisture content instead of the value to the dry state. The relation is then

$$(m_i)_{calc.} = 12 + \frac{S_{v(G-12)}}{\rho} \qquad 3$$

where $S_{v(G-12)}$ is the percentage volumetric shrinkage from green to 12 per cent moisture content and the density ρ is expressed in g/cc.

Intersection points for the 131 species referred to above have been calculated using equation *3* and have been compared with the average of the radial and tangential intersection points obtained from the shrinkages from green to 12 and 5 per cent moisture content. All calculations have been made using shrinkages determined after reconditioning. The results are shown in Fig. 4.

The behavior of the Australian and Pacific Island species was significantly different, but the average correlation coefficient was found to be 0.86, i.e., 75 per cent of the variation in the intersection point calculated using equation *3* was accounted for by the variation in the mean intersection point obtained from the shrinkage-moisture content relationship.

The regression coefficients in the relations between the two sets of values were both 1.027 with a standard error of $\pm$ 0.052. Since they are thus not significantly different from unity, the regression equations may be written as follows:

Australian species

$$(m_i)_{calc.} = (m_i)_{mean} - 1.6$$

Pacific Island species

$$(m_i)_{calc.} = (m_i)_{mean} + 0.9$$

This correlation is better than that between unit shrinkage and basic density, as in order to eliminate some of the errors the calculations have been made over a smaller range of moisture contents. However, the correlation is only useful in providing a rough estimate of the intersection point when none is available by other means. The difference between the behavior of

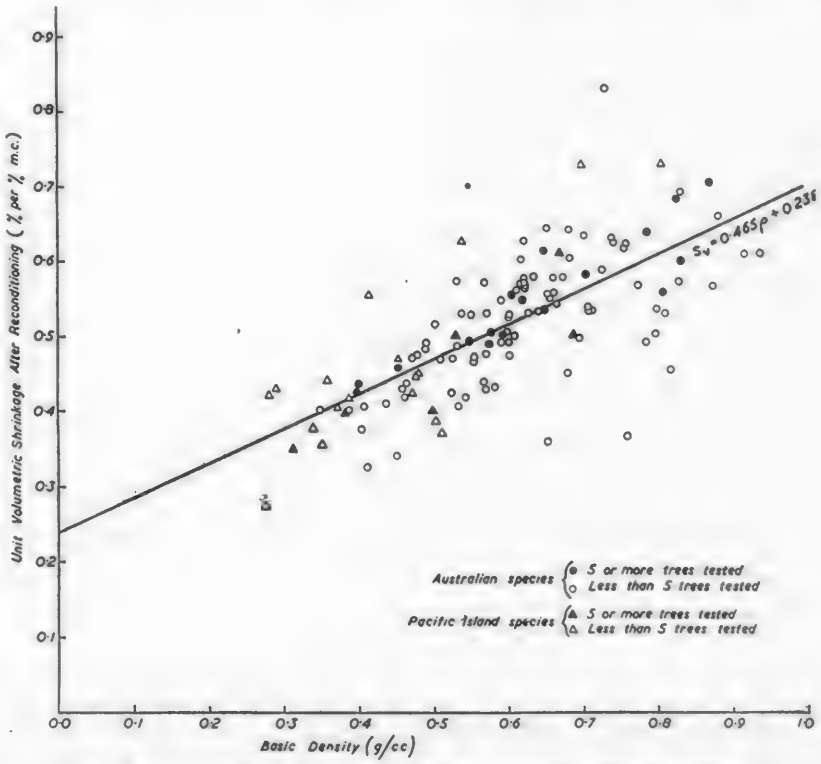

Fig. 3.—Correlation between unit volumetric shrinkage and basic density.

Table 5.—VARIATION IN EQUILIBRIUM MOISTURE CONTENT AND IN SHRINKAGE INTERSECTION POINT OF CERTAIN SPECIES

Species	No. of Specimens	Intersection Point (%) (from shrinkage–moisture content relationship) Tan.	Rad.	Mean	Equilibrium Moisture Content (%) at Various Humidity Conditions (all adsorbing) 1	2	3	4	5	6
Araucaria klinkii Lauterb.	4	29.4	27.6	28.5	5.5	8.4	10.1	12.5	15.9	17.4
Artocarpus sp.	4	17.2	13.9	15.5	5.2	7.1	8.5	10.6	13.0	14.1
Intsia bijuga (O.K.) Colebr.	4	20.4	17.5	19.0	5.1	6.6	8.0	10.1	12.5	13.8
Pometia pinnata Forst.	4	28.7	26.1	27.4	5.6	8.4	9.9	12.6	15.6	17.2
Pterocarpus indicus Willd.	4	18.0	17.2	17.6	4.0	5.6	6.7	8.8	11.3	12.8

the Australian and of the Pacific Island timbers is difficult to explain, and only emphasizes the approximate nature of any estimate of the intersection point using this method.

Relation Between Shrinkage Intersection Point and Equilibrium Moisture Content

It may be seen from Fig. 4 that for some Pacific Island species tested, values of the intersection point of the order of 16 per cent moisture content were observed instead of the more usual values of 25 to 30 per cent. The moisture content of the test specimens when the initial measurements were made was in most cases over 70 per cent, so that any error in the intersection point due to shrinkage of the green wood before measurements were made seemed unlikely.

A comparison of the equilibrium moisture contents of these species with those of species of normal intersection points has been made by exposing similar specimens of all species to atmospheres of various controlled relative humidities until constant weight was attained. The equilibrium moisture contents at each stage are shown in Table 5.

It may be seen that the equilibrium moisture contents of the species with low intersection points are considerably less than those of the species with normal intersection points. This provides further evidence that the shrinkage intersection point is a characteristic property of the species and is related to its hygroscopicity.

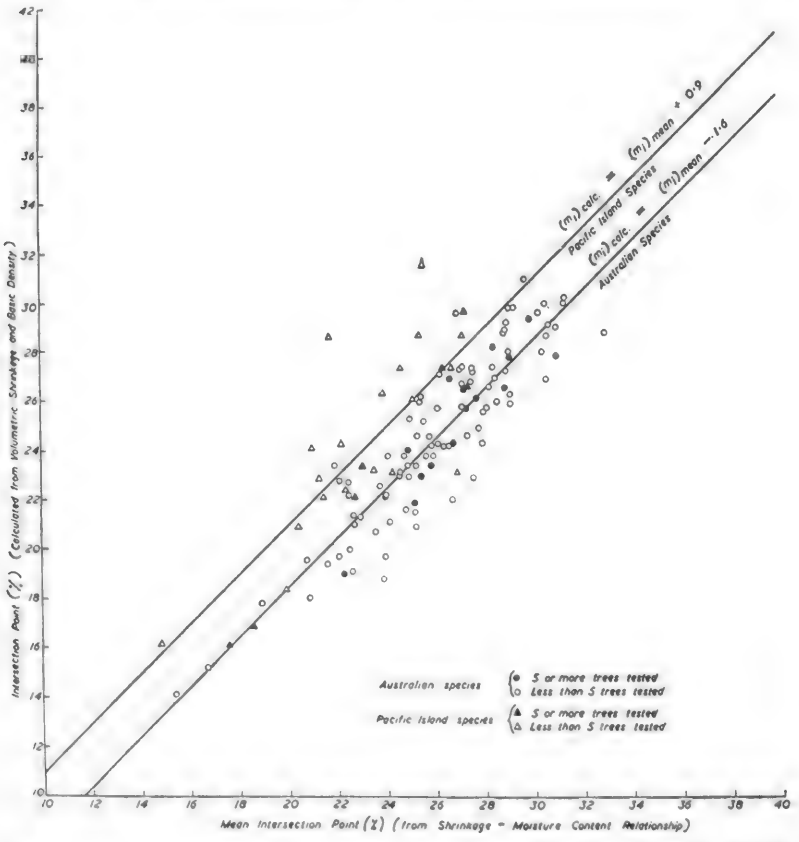
Intersection Point (%) (Calculated from Volumetric Shrinkage and Basic Density)
Mean Intersection Point (%) (from Shrinkage – Moisture Content Relationship)
(mi) calc. = (mi) mean + 0.9
Pacific Island Species
(mi) calc. = (mi) mean – 1.6
Australian Species
Australian species
5 or more trees tested
Less than 5 trees tested
Pacific Island species
5 or more trees tested
Less than 5 trees tested

Fig. 4.—Correlation between intersection point calculated from volumetric shrinkage and basic density and that obtained from shrinkage-moisture content relationship. (Note: All shrinkages determined after reconditioning.)

Conclusions

The more important results which have been obtained from the present investigations may be summarized as follows:

1. In the absence of collapse, the mean of the tangential and radial shrinkage intersection points when determined using 1 in. × 1 in. × 4 in. specimens is not significantly different from the value determined using small basic shrinkage specimens.

2. The intersection point calculated from the shrinkages from green to 12 and to 5 per cent moisture content is not significantly different from that determined by using the whole linear portion of the shrinkage-moisture content relationship. However, the intersection point calculated from the shrinkages from green to 12 per cent moisture content and to the oven-dry state is definitely too high because of the non-linearity in the relationship at low moisture contents.

3. When collapse occurs, the shrinkage intersection point is greater than in material free from collapse.

4. The tangential shrinkage intersection point is consistently greater than the radial value, but the mean of these two is not significantly different from the value obtained from volumetric shrinkage measurements.

5. The correlation between unit volumetric shrinkage and basic density for 131 Australian and Pacific Island species investigated is poor, only 57 per cent of the variation in unit volumetric shrinkage being accounted for by the variation in basic density.

6. It is possible to make a rough estimate of the shrinkage intersection point from the volumetric shrinkage from green to 12 per cent moisture content and the basic density. However, the correlation coefficient between this estimated value and the value obtained from the shrinkage-moisture content relationship was only 0.86 and the regression lines were significantly different for Australian and Pacific Island species.

7. A correlation between the shrinkage intersection point and the equilibrium moisture content at a given relative humidity was evident for five species whose intersection points were within the range of 15 to 28 per cent moisture content.

Acknowledgment

The author is grateful to Miss N. Ditchburne, Division of Mathematical Statistics, C.S.I.R.O., for obtaining the regression equations.

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Chemical Seasoning of Lumber[1]

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Application of chemicals to wood before seasoning lessens drying stresses and imparts other beneficial properties to the wood. Three methods of applying chemical seasoning agents and properties of chemical seasoned wood are described. Effectiveness of various agents is evaluated and their present and future status discussed.

Introduction

LUMBERMEN HAVE HAD TO CONTEND with degrade losses from checks and splits ever since the first tree was cut. Checking is a natural tendency of lumber when exposed to rapid drying conditions while still green and swollen. This tendency costs the country millions of board feet of lumber annually with a resulting loss of millions of dollars. This loss is suffered by everyone from the manufacturer of the lumber down to the man who buys the finished fabricated product.

Much has been done throughout the years to overcome the checking of lumber. Better piling methods and more efficient kilns have contributed greatly toward solving this problem. Another more recent approach has been through the use of chemicals.

Cause of Checking

Checking occurs in lumber because of uneven shrinkage throughout the piece as its moisture content decreases. This natural uneven shrinkage within the piece creates stresses which tend to rupture the fibers causing checks.

Uneven shrinkage has two main sources. One is the difference in shrinkage between the surface and the interior of a piece resulting from variations in the moisture content. The second is the characteristic of all commercial woods to shrink more along the annual rings (tangential direction) than across the annual rings (radial direction). In drying ordinary lumber, the shrinkage differences cannot be eliminated, but drying conditions can be adjusted so as to lessen stresses and minimize checking.

Chemical Seasoning: The idea of using chemicals to lessen drying stresses is not new. Several hundred years ago people soaked wood in sea water before drying it to reduce surface checking and for many years salt has been spread over lumber as it is piled for air drying. But the process was not understood until about 1930 when the U.S. Forest Products Laboratory began to study it.

From the facts that the vapor pressure of water diminishes when chemicals are dissolved in it and that a dissolved chemical diffuses from a zone of high concentration to one of low concentration, the Forest Products Laboratory formulated the following principles:

1. A water soluble chemical will diffuse into water in green wood and simultaneously, water in green wood will diffuse into the chemical solution in which it is submerged.

2. When a chemical diffuses into the water in unseasoned wood, this water becomes a chemical solution that has a vapor pressure less than that of water. The treated portion of the wood tends to retain its green dimensions while being dried at a relative humidity in equilibrium with the vapor pressure of the chemical solution.

3. The presence of the chemical in the fine swelling structure of wood decreases its normal shrinkage.

All chemical seasoning agents operate on these principles. However, in practice the anti-shrink effect is generally considered too slight to be of consequence.

How Chemical Seasoning Works

Two items should be remembered in discussing chemical seasoning. They are: 1. Chemical seasoning is in reality a preseasoning treatment. The conventional methods of drying must still be used. 2. Chemical seasoning does not depend on any chemical reaction between the wood and the chemical used.

If the outer portions of a board are saturated with a given chemical, they tend to remain moist as long as the vapor pressure of the surrounding air is equal to or higher than that of the solution in the wood. The high moisture content of the surface zones of the treated wood does not decrease the drying rate because the water in the untreated portion will have a normal high vapor pressure and will move toward and be evaporated from the surface. If a proper balance exists between the relative humidity of the air and the vapor pressure of the solution in the wood, the moisture content of the surface fibers will remain high enough to prevent their shrinkage and

[1] Presented at meeting of FPRS Mid-South Section, Nov. 7–8, 1955, in Memphis, Tenn.

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thus prevent surface checking.

Like ordinary lumber, it is a lowering of vapor pressure toward the surface that allows treated lumber to dry. Ordinary lumber depends upon a reduction in surface moisture to affect a lowering of vapor pressure while treated lumber depends on a chemical to lower the surface vapor pressure.

Combining Seasoning Agents

The primary function of a chemical seasoning agent is to improve wood drying. However, various seasoning agents can be combined to impart certain of their beneficial properties to the wood.

For example, combining a crystalline agent such as salt, urea, or monoammonium phosphate with a noncrystalline chemical such as glycerine, diethylene glycol, molasses, invert sugar, or corn syrup gives a maximum anti-shrink affect. Resin-forming chemicals increase the hardness of wood. Urea has the property of combining with lignin in hardwood to form a thermoplastic material. The ammonium radical of certain chemicals darkens wood, giving it a fumed appearance. Many combinations are possible to impart a desired characteristic to the lumber.

Methods of Applying

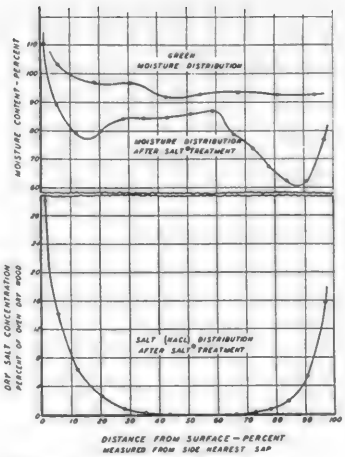
Several methods of applying a chemical seasoning agent are possible. Each has its place and must be selected to fit the individual operation.

Steeping: In the earlier experiments wood was submerged and steeped in a solution of the chemical from one to four days for each inch of thickness. This method was effective but was suitable for only small quantities of high priced material. The enormous tank capacity required makes steeping impractical for a large scale operation.

Spraying and Dipping: When lumber is dipped or sprayed in a chemical solution, the piece size and the concentration, viscosity, and temperature of the solution affect the quantity of chemical that adheres to the surface of the lumber. This means the solution must be adjusted for each change of specie or dimension to be treated. For example, oak requires the presence of certain amount of chemical/M.B.F., beech requires another amount, etc., down through the list of species. This means that every time a mill cuts a different species, the solution must be adjusted for that species. Also, 8/4 lumber has twice the board foot volume of 4/4 lumber but only slightly more surface area to take treatment. This means the solution must be adjusted for every change in lumber dimension.

To further complicate the situation, a saturated solution of chemical is used to secure the required treatment in the shortest time. Therefore, to change the concentration of the solution, heat must be applied to increase the solubility of the chemical agent. Another method is to change the viscosity of the solution. This can be done by adding starch, bentonite, or any of a number of thickening agents. This, however, results in sticky, messy lumber to handle.

In general, dipping or spraying is restricted to specialty items or small scale operations.


MOISTURE CONTENT - PERCENT
GREEN MOISTURE DISTRIBUTION
MOISTURE DISTRIBUTION AFTER SALT* TREATMENT
DRY SALT CONCENTRATION PERCENT OF OVEN DRY WOOD
SALT (NaCl) DISTRIBUTION AFTER SALT* TREATMENT
DISTANCE FROM SURFACE - PERCENT MEASURED FROM SIDE NEAREST SAP

* Morton Lumber Cure.

Fig. 1.—Comparison of moisture distribution and salt (NaCl) distribution after Chemical seasoning treatment.

Dry Spreading: A dry crystalline or powdered chemical may be applied by spreading it directly on the surface of the lumber. The lumber is bulk-piled with a layer of chemical between each course so that both faces of the board are in contact with the chemical. In a few days the chemical has all dissolved and diffused into the wood, after which the lumber is repiled on sticks for air drying or kiln drying.

No special equipment is needed for this method and no expensive installation is required. The lumber to be treated can be easily selected and treated at the most desirable location. The dry spread method has proven the most successful in most cases.

Properties of Chemical Seasoned Wood

Chemicals retained in lumber may modify the properties of the wood, depending on their kind, amount, and depth of penetration. As the effect of the chemical may be either good or bad, seasoning agents should be chosen with the end use of the seasoned wood in mind.

Corrosion: Most salts are corrosive. For this reason care must be taken to include a corrosion inhibitor with this group of seasoning agents. Buffered sodium chloride such as Morton Lumber Cure is effective in this group.

In general, organic compounds are not corrosive. However, they are not considered as satisfactory as buffered sodium chloride for various reasons such as ease of handling, discoloration, and in some cases price.

Condensation: To be an effective chemical seasoning agent, an aqueous solution should have a relative vapor pressure in equilibrium with a relative humidity of about 75 per cent. The relative humidity with which a chemical solution is in balance establishes the minimum relative humidity to which the wood may be exposed without shrinkage of the surface fibers. Treated wood exposed to relative humidities higher than the relative vapor pressure of the solution will tend to condense moisture. For rapid drying the relative vapor pressure of the chemical should be low and to reduce condensation the relative vapor pressure should be high. Therefore a chemical should be used that gives a good compromise between the two extremes.

Since the chemical is concentrated in the outer fibers so that much of it is removed in surfacing the lumber and since dry wood products are usually kept dry, it is easy to overemphasize the seriousness of condensation in chemical seasoning.

Electrical Conductivity: Electrolytes impregnated into wood materially reduce its electrical resistance. If high electrical insulation is required, salts should not be used as chemical seasoning agents. A small amount of salt in wood will increase its conductivity by many times.

Influence on Color: The natural color of wood is not altered much by sodium chloride, or buffered sodium chloride. Other chemicals, particularly the ammonia compounds, such as urea, monoammonium phosphate, and ammonium sulfate tend to give the wood a fumed appearance that is increased by high kiln temperatures. Invert sugars and diethylene glycol do not alter the color of wood unless the drying temperature exceeds 150°F.

Effectiveness of Chemical Seasoning Agents

Chemicals: Few chemicals are satisfactory seasoning agents. A good one must be low priced and quite soluble in water. Its saturated solution should be in equilibrium with about 75 per cent relative humidity and it should be noncorrosive to any metal fastenings and kiln parts. Only buffered sodium chloride, buffered urea

aldehyde, and, for some uses, urea meet these requirements.

Influence of Drying Methods: The method of drying treated lumber has more effect on the drying rate and seasoning losses than the chemical treatment. A predrying treatment supplements, but does not replace the recognized seasoning factors of temperature and relative humidity. Although chemically treated lumber can be safely kiln-dried at relative humidities ruinous to similar untreated material, treated wood has its own critical temperatures and relative humidities.

Drying Time: In general, other factors being equal, treated and untreated lumber should dry at the same rate. Chemically treated stock can be expected to dry faster than untreated material only when the treated stock is dried by a more severe drying schedule.

Drying Degrade: The method of drying the lumber and the chemical seasoning agent used both have an effect on drying losses. However, when a chemical is chosen giving a vapor pressure in equilibrium with a relative humidity of approximately 75 per cent and drying conditions are adjusted to the moisture retention properties of the chemical, degrade losses can be cut up to 95 per cent.

Present and Future of Chemical Seasoning

At present, chemical seasoning is in its infancy. The process has been known and investigated for over 25 years but the surface has been barely scratched. Much still remains to be learned. At the present time, one company, the Bay Chemical Company, has ventured to produce and market a commercial chemical seasoning agent. Up until about 3 years ago they met with little acceptance. However, since that time numerous mills and woodworking plants have found that check-free lumber is definitely an asset to business. Mills get less degrade and more repeat orders for treated lumber and fabricators find their cutting yields greatly increased.

Chemical seasoning strives for a quality product. Reduced drying time and the imparting of special properties to the wood are added features but at present are not enough to make chemicals universally accepted as a tool to seasoning lumber. However, as more and more people learn that check-free lumber is better than lumber with surface checks closed during drying, chemical seasoning is gaining popularity and is slowly but surely coming into its own. The day is coming when chemicals will be in common use to help season the woods difficult to dry normally.

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Engineering Design of a Veneer and Plywood Plant[1]

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Broadly discusses from an engineering viewpoint the following factors which affect the design of a modern veneer and plywood plant: plant location, climatic conditions, transportation, character and availability of timber supply, labor, type of product, markets, and extent of integration of the project. Summarizes detailed engineering data required in execution of a rational design of a specific plant.

THE DESIGN OF A VENEER and plywood plant, engineered or otherwise, must be conceived in compromise and dedicated to the proposition that the raw material is as God makes it.

Plywood markets do not exist in a forest nor do trees grow in the center of a plywood market. Thus, the compromising begins.

It has been represented to the writer on several occasions that the millennium had arrived and that there existed at a heretofore inaccessible location a forest of perfect trees which were all true cylinders and contained no defects. One plant was actually designed and built to process such perfect logs but the local sheriff soon relieved the stockholders of any further responsibility of ownership.

It behooves the plywood plant designer and his employer not to forget the opening dedication.

This discussion relates to an engineering design problem which turned out to have so many ramifications that any attempt to cover it in a single paper would have made the discussion valueless. This paper will be limited to a discussion of the engineering of what may be termed the external aspects of the design of a veneer and plywood plant, leaving for a subsequent discussion the engineering design of the production line itself.

Specifying the Problem

Since an engineering problem is under discussion, good engineering principles should be followed by specifying exactly what the problem is. This can be done by giving the design engineer the answers to the following questions:

Where?
How much?
Into what?
From what? Delivered when and how?
Degree of integration?

[1] Presented at Session XIV, Veneer and Plywood, FPRS Tenth National Meeting, June 4–7, 1956, Asheville, N. C.

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Where? Where the plant is to be built will or should be a factor in its design. It is obvious that climatic conditions will have a direct bearing on the type of building required and on the steam requirements. Climate also affects the efficiency of labor; hence, the size of the plant for a given capacity. Climatic conditions also indirectly affect equipment selection since logs available in a cold climate such as the Scandinavian countries and Canada are of small diameter and can only be economically cut in short lengths.

The cost and availability of labor, both skilled and unskilled, influence to some extent the selection of equipment. The average skill and aptitude of the available labor will also influence both size of plant and selection of equipment.

How much? How much a mill shall produce or its capacity must be defined in reference to a unit of time. Due to the varying number of days worked per year, per month, and per week in various areas around the world, the unit of time should be reduced to days and preferably to shifts.

For design purposes, it is a good general rule to figure one shift per 24 hour day at the green end, two shifts on the driers and presses.

Into what? This discussion relates to a plywood plant design so logs are obviously being converted into plywood. However, a client who expected to produce architectural plywood might be slightly disappointed with a mill designed to make drawer bottoms and mirror backs, regardless of the quality of the engineering.

This example will illustrate the need on the part of the designer for exact and detailed information as to the specific type or types of plywood to be produced and the range of sizes and thicknesses.

From what? A veneer and plywood plant uses timber as a raw material. The engineer who is responsible for plant design must have detailed data on the specific raw material to be processed. In other words, he must have a raw material specification. This he can formulate from the answers to the following questions:

(a) Predominant species?
(b) Secondary species, if any?
(c) Will timber be received as long logs or as pre-cut blocks?
(d) If in long lengths, what is the maximum length and average length?
(e) What will be maximum, minimum, and average diameter?
(f) Will logs be received seasonally or at a reasonably uniform rate month by month?
(g) How will logs be delivered to mill site? By water, rail, truck, or all three?

Integration? The degree, if any, that a veneer and plywood plant is integrated with other wood converting units at the same location influences the design of the plant in many respects. Consequently, the plywood plant designer should have full information on existing or potential integration. Some of the units which may be combined into a wood converting complex are sawmill, planing mill, door plant, steam generating plant, power generating plant, chip mill, pulp mill, paper mill, chipboard plant, insulation and hardboard plants.

It can now be assumed that the plywood plant designer has sufficient data to prepare a complete detailed specification of his design problem.

He will next make a rough determination of the steam, power, and water requirements and work out an overall wood balance between the total volume or tonnage of wood entering the plant, and the tonnage of wet waste, tonnage of dry waste, and tonnage of finished product.

If the plant to be designed will be located in the hinterlands where central station power is not available at a reasonable price, the above figures will usually indicate a fuel deficiency. In most areas where such conditions prevail, neither oil nor coal are available at a reasonable cost. This leaves waste wood from some other source as the only solution to the fuel deficiency problem. Sometimes wood waste can be purchased from an existing nearby sawmill. But if this is not possible, the only solution is to integrate a sawmill into the picture with the veneer and plywood plant.

The peak and average hourly electrical load for each shift is now known. This power will either be purchased or generated at the plant site in which case the generating facilities are generally consolidated in a combination boiler and power house. In either case, the plywood plant designer need only be concerned with electrical power distribution once he has determined in detail the requirements.

Unfortunately, the steam problem is not as simple. The plywood plant not only uses steam but it also supplies fuel for steam generation. This fuel starts to develop at the station where logs are sawed into blocks and it continues to develop down through the mill to the shipping dock. Consequently, the location of the steam generating facilities and the plywood plant become interrelated. Further, if a sawmill has been added to supply a fuel deficiency, its location or at least the method of delivery of wood waste to the steam plant becomes interrelated with the plywood plant and its waste conveyor and hogging system.

Log or block storage, either in a yard or pond, must be provided. The storage capacity will be determined not only by the mill capacity but also by the method and timing of log deliveries. In some localities all the logs for an entire year's production will be received over a one- to three-month period. In other areas, deliveries each month will be reasonably constant.

If the species being processed floats, a pond provides the most economical log storage and means for handling and sorting. In Finland, ingenious means are employed for handling hardwoods in the water which is kept open by pneumatic de-icers during the winter.

The species being processed may or may not require heat treatment prior to cutting on the lathe. Heat treatment may only be required during certain months of the year, perhaps only part of the species being processed requires heat treatment, or perhaps heat treatment will only be required when cutting the heavier thicknesses. In any event, if any heat treatment is required, a study must be made to determine the maximum volume which must be so processed per shift and the time required for processing so that adequate space may be allocated for this operation and the proper handling facilities provided.

A detailed discussion of the pros and cons of heat treating logs and/or blocks prior to cutting on a rotary lathe and the various methods and equipment which may be employed to effect heat treatment is a broad study in itself which cannot be included in the scope of this discussion. It is only assumed at this point that a decision has been made that heat treatment is not required or that it is required and to what extent.

The debarking and round-up problem now presents itself. The decision on this problem may affect the location of the station where logs are sawed into blocks and the general yard or pond arrangement with its materials handling facilities.

Is the debarking to be done manually or mechanically or by a combination of both? If the timber being processed requires heat treatment before cutting and the decision is to bark mechanically, the question also arises whether to bark before or after cutting to block length. If blocks averaging in the neighborhood of 28 inches or less in diameter are being processed this general problem is further complicated by the question of whether to "round-up" as well as bark prior to delivery of the block to the cutting lathe.

It may be argued and figures presented which appear to prove that some of the tropical species, especially those having thin bark, can be debarked more economically by hand in low wage areas than by machine. It has been the writer's observation that the debarking and the cutting lathe situation is exactly the same as the cutting lathe and the clipping. If either the debarking or the clipping is an interrelated operation with the cutting in the overall process, lathe production suffers.

Human nature in many ways is the same the world around. The lathe crew tends to set its pace to the rate blocks are being barked. The barking crew tends to bark just a little behind the lathe requirements. Likewise, the lathe may at times bury the clipping but clipper crews never set a pace for the lathe.

With mechanical barking it becomes obvious to management that something is wrong if there is not at all times a bank of debarked blocks ahead of the cutting lathe. Thus, the barking operation does not exert a psychological brake on lathe production.

If the average block diameter is, for example, 28 inches or less, the number of blocks cut per shift will be substantial. Thus, the total time lost per shift at the cutting lathe in "rounding up" irregular blocks, even though they have been mechanically debarked, may reach a substantial percentage of the total shift hours. If a mill wants to cut 150 to 300 or more blocks per shift, the cutting lathe should be relieved from at least part of the job of reducing the blocks to some semblance of a cylinder.

Great advances have been made in the past few years in the development of mechanical debarkers and for some types of plywood operations, available units may meet all requirements. For other types of operations, no equipment currently available gives the optimum answer to the debarking and round-up problem, either from the standpoint of the results produced or the block handling involved.

Before leaving the debarking and/or round-up problem, it may be apropos to briefly discuss the related subject of block cleaning. In the manufacture of plywood generally, with the exception of that made from fir and a few other species, it is usual to allow 10 to 15 thousandths of an inch as a maximum per side for sanding. Consequently, the faces must be cut smooth. Scratches and torn streaks caused by knife nicks cannot be tolerated nor can tight and loose spots which are often caused by partially or completely whetting out nicks in the lathe knife. 99 per cent of the nicks are caused by foreign material in the block, mostly sand and gravel.

Such attrition of the lathe knife is looked upon in many mills as a necessary evil which can only be combatted by more frequent knife changes. If the lathe is cutting 5,000 to 6,000 linear feet of veneer per hour, which can be done in a well-engineered mill even on small hardwood blocks, then a shutdown for a knife change or for any reason becomes expensive.

The answer to maintaining a sharp knife is to cut only clean blocks. Much can be done to improve the cleaning of blocks by providing space and simple facilities for this operation. It is still simpler to keep blocks clean by providing proper handling facilities between the debarking station, manual or mechanical, and the cutting lathe.

An appreciation by management of the savings which may be made by delivering only clean blocks to the cutting lathe is often as important a requirement and sometimes more so than providing the facilities.

Material Handling

At this point it may be well for the plant designer to consult his wood balance computations and make some tentative decision as to hogging equipment and material handling facilities required. The magnitude of the problem of simply moving material, particularly waste, from one point to another is not generally appreciated. The following figures may be quite illuminating.

On the basis of actual cubic volume (not log scale), the wood input of an all rotary cut plywood plant will be from 2 to 3¼ times the cubic volume of the plywood shipped.

For example, a mill producing 150,000 square feet of ¼-inch plywood per day would have a wood output of 3,125 cubic feet. If this were a birch mill, the input volume would be from 9,000 to 10,000 cubic feet of wood. Or, if the mill were processing Gaboon (Okoume) the input volume would be from 6,200 to 7,000 cubic feet. In the former case, the waste would average 6,375 cubic feet and in the latter case 3,475 cubic feet per day.

True, 150,000 square feet of ¼-inch plywood is a respectable daily production but if this is divided by five for the small mill, then we are still dealing with a waste volume in round figures of 700 to 1,300 cubic feet per day. This volume is still quite a load for a man with a cart or even a man with a cart and a mule, whether the man is paid a dollar an hour or a dollar per day.

Remember this is only the waste volume. As a minimum, the total input volume must be moved into the yard or pond, then moved out and moved into the mill. If the wood has to be heat treated before cutting, the handling of the total input volume is about doubled.

The wood balance computations will show the volume of tonnage of waste which will develop at the bolt sawing station, if the wood is not received as pre-cut blocks. This waste will be in the form of butt ends or "lilypads" or defective wood plus sawdust. If fuel is a critical item, this waste must be transported to the boiler house. If the logs are of large diameter, these butt ends must be split or otherwise reduced in size. In any event, the fact remains that all this waste including the sawdust must be moved, which is an item of cost as much as clipping, splicing, pressing, sanding, etc. It deserves, but seldom receives, as much engineering study as the cost of these other operations.

Most of this waste is solid wood. It may or may not be economical to hog it. If it is to be hogged, it may influence the type and size of the hog or hogs selected.

The next item of waste to develop is bark. If the bark is removed by a rossing head, it is eliminated as a hogging problem. If removed otherwise, the bark usually becomes a waste item to be included in the hog considerations. Again, the fact remains that it must be moved.

Some species of bark cannot be put through some types of hogs. Because bark usually carries in it considerable abrasive material, it increases hog maintenance. Situations sometimes exist which make it more economical to install a separate hog for bark only than to convey it to the hog serving the cutting lathe. If the debarker is also a round-up lathe, the volume of waste developed at the debarking station will exceed the waste developed at the cutting lathe exclusive of the cores.

Whether or not waste material in quantity will develop back of the cutting lathe from turning the block into a cylinder, the lathe must still be provided with a waste conveyor. This conveyor will be discussed at this point since the lathe waste and the hog to which it feeds should be considered as part of the yard, steam plant, hog, hog house, and waste handling arrangement problem.

Time is the controlling factor in the handling of waste back of the cutting lathe. Production hours lost due to lathe stoppage caused by accumulations of waste back of the lathe because of the lack of a conveyor or because of conveyor and/or hog failures would have amortized many a

mill before it was fully depreciated on the books. Manual waste removal back of a lathe is costly even if the labor is free.

The peak loads which may develop over any 30-second to 2-minute periods from all sources which may discharge onto this conveyor can easily be computed. The conveyor should be designed for such peak loads rather than for an average load over a 15-minute or half-hour period. Under most circumstances, a relatively high speed belt conveyor will best meet the requirements. If permitted by the general layout and arrangement, this conveyor should discharge directly into a hog without change of direction in the flow of waste material.

With a variable speed drive, a nominal 8-foot lathe will develop a surprising volume of waste in 30 seconds, particularly if the blocks are not previously rounded up to an approximate cylinder. This means that the design engineer must be realistic in his selection of hog size and the motor to drive it.

Due to the noise factor and to help the general problem of elevations, it is usually desirable to install the hog handling the waste from back of the lathe in a separate hog house, although there may be situations which make the installation of the hog in a pit directly below the lathe the most desirable on overall balance. Such an arrangement often eliminates a conveyor. However, it also means that if the hog is "down" the lathe is also "down." If the waste is conveyed outside the mill to a hog, a bypass can be installed in the conveyor through which the waste can be discharged into the yard during a temporary failure of the hog and lathe production still maintained.

Many a hog has been unfairly condemned when its failure to function was caused by lack of adequate provision for carrying away the hogged material. The conveying means for this material must also be designed for the peak load as well as the infeed conveyor and the hog.

The hogged waste can either be mechanically conveyed or blown from the hog to the storage bin which is usually in or adjacent to the boiler house. This conveying problem can become complicated and costly unless at this stage in the engineering, the location of the hog or hogs is properly correlated with the fuel storage bins at the boiler house.

The transportation of high moisture content hogged veneer waste by a blower system involves specialized engineering and the plywood plant designer is well advised to consult the specialist.

The fact should not be overlooked that this material will freeze in cold climates and lock a mechanical conveyor if the conveyor is shut down overnight with chips in transit.

The cores dropped by the lathe constitute one of the largest single items of waste. They represent a substantial tonnage which should be handled a minimum number of times.

Because the usual core is not more than 7 or possibly 8 inches in diameter, the conveyor provided for their transport away from the lathe will seldom handle substantially larger diameters. The core conveyor from the lathe should have capacity not only for the usual diameter core but should also be capable of handling reject blocks. Too often $5 worth of lathe time is expended in an attempt to recover $1 worth of veneer from a defective block.

Before a conveyor is engineered for carrying the cores away from the lathe, a study should be made as to the best method of disposal which will yield a maximum return for a minimum handling cost. If cores are required as fuel, provision must not only be made for transport but also for firing them. If power is being generated and the fuel supply critical, they cannot be fired as chips since the power required for chipping carried back through the generators and the boilers increases the fuel requirement to the point of diminishing returns.

The location of the plant and the extent of integration will have a vital influence on the best answer to the core disposal problem.

An item which may well be considered as part of the "external" engineering is that of maintenance facilities. If the plant is located in the hinterlands, a well-equipped machine shop is an absolute necessity. A well-planned warehouse arranged for tight control of replacement parts and supplies is also a vital requirement. Even in a locality where machine shop facilities are readily available with the services of specialists, a plant of any size should have well-planned facilities for both preventive and emergency maintenance. Such facilities will include a separate grinder room where the precision grinder can be installed and be free of vibration.

All too often maintenance facilities are an afterthought and their location and adequacy are given no engineering study. As a result, some out-of-the-way corner of the production mill is ultimately labeled "maintenance" on a blue print. The plant maintenance then usually reflects this casual approach.

Wherever plywood plants are located, it usually rains once in awhile if not every day. In many locations floods are a potential hazard. Sound engineering indicates that some planning and study should be given to the drainage problem during the design stage to minimize the effect on production of not only normal rainfall but also to some reasonable degree an abnormal situation. Tractors working hub-deep in mud in the mill yard or production workers sweeping water off the mill floor are not conditions which promote good profits.

The plant site may have been selected prior to the entrance of the plant design engineer into the picture. In such a case, he must prepare a statement of the problem, make his studies and computations, and then arrange all the facilities to the best possible advantage within the limits of the available space, its topography, and the transportation facilities.

An error of judgment at this point can be serious. A machine can be pulled out of the production line and replaced but a mill building or a boiler house do not move easily.

If only the general area in which the plant is to be located has been determined, a careful study should be made of all possible sites in the area and a written evaluation prepared of each site. Some of the following factors are worthy of consideration in making such evaluations.

Cheap and convenient transportation for the incoming raw material and the outgoing finished product is one of the most important factors. The original delivery of the heavy plant machinery is a transportation problem which should not be dismissed lightly. Transportation of personnel to and from the mill may also be a factor which must be weighed when selecting a plant site.

Water transportation of raw material is usually the most economical and often the only means available. The ideal plant site would be on navigable water. However, a wide water front does not necessarily mean either cheap or convenient transportation. It is one thing to float logs onto a beach but handling finshed plywood in lighters through the surf to a ship standing a mile or more off shore is quite an operation.

The plant site should be on high ground and well drained so as to be free of the possibility of flood damage.

An ample water supply should be available not only for the usual plant requirements but also for fire protection.

The possibilities of an artificial log storage pond should not be overlooked if a natural one is not available and the species being processed float.

Even with hardwoods stored on land, a substantial quantity of water

may be required per day for spraying to reduce log deterioration during the summer months.

Dredging, dock facilities, grading rail trackage, truck roads, personnel housing, and power generating facilities all cost money. Here again, a compromise may be in order by eliminating a site with excellent natural advantages for one less ideal if the latter avoids an expenditure for one or more of the above items.

In the final analysis, it is people who make a plant successful, not the equipment. Consequently, it may be far wiser to locate the plant where good people are willing and happy to live and work even though it involves compromising in other directions.

The engineering design of a veneer and plywood plant does not begin with a flow chart of the manufacturing process and a selection of the production equipment. The fact that the total cost of such a mill will be three to four times the cost of all the production equipment required in the manufacturing process highlights the need for an engineering approach, thorough investigation, and the execution, at least tentatively, of the external design, prior to the design engineering of the production facilities.

The Care and Maintenance of Veneer Knives[1]

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Veneer knives must be properly maintained to assure continuous lathe operation. Major steps of knife manufacture are explained and the importance of a straight, keen edge is stressed. Considers the effect of positioning the knife on lathe performance and veneer quality and discusses proper grinding practices.

TO UNDERSTAND THE IMPORTANCE of care in the handling of a veneer knife, it is necessary to know a few things about the steps of manufacture.

A veneer knife is a bi-metal cutting tool which requires the welding together of two types of steel. The inlay which makes up the cutting edge is made of a high-grade alloy tool steel. This inlay bar is forced under tremendous pressure in the welding operation into a bar of soft iron backing at a temperature of approximately 2300° Fahrenheit. The knife blank is then put through a rolling mill to reduce its thickness to a figure which will allow adequate stock for the machining and grinding operations.

The second important step is the hardening and tempering of this veneer knife. In view of the fact that the inlay is of a type of steel which does harden, it will of necessity change somewhat in volume. In contrast, there is no volume change in the backing steel because of its extremely low carbon content. Recognizing the fact that these two steels have been made into one integral part, and taking into consideration the change in volume of one of the two components, it can be seen that in the hardening of a veneer knife distortion must be controlled.

The final steps in manufacture are the machining, surface grinding, sharpening and straightening of the veneer knife. These operations must be divided into several steps in order to avoid bowing or twisting the knife due to removal of too much stock at a time from any one part of the blank.

All of the above steps in manufacture are carefully controlled in order that a finished veneer knife may be straight and conform to close tolerances in thickness and width from end to end.

In resharpening knives in the field, one sometimes finds poorly maintained grinding equipment that will not give accurate service in sharpening a knife; grinding cannot be done accurately, producing knives that are uneven in width from end to end. When such a knife is put into the lathe, the lathe operator has great difficulty in straightening the edge. He is forced to try with the jacking screws to bring the low points in the knife up to and even with the high points. Such a practice will put the knife under heavy strain in the cutting operation. It is impossible to straighten out the edge completely by this method, with the result that the knife cuts above chuck center in some spots and below center in others.

Material produced on such a lathe will be tight in places and loose in others. Veneer of this sort is sometimes described as being "tinny", in other words it has a tendency to pop through from one side to the other when pressed.

In certain operations the veneer knife is subject to considerable wear on the side opposite the bevel, at the cutting edge. This wear is due to the rubbing of the veneer as it passes through the opening between the knife and the nose bar. Such wear is quite often irregular, being heavier at one point along the cutting edge of the knife than it is at another. No amount of rebeveling will straighten this edge unless the knife is reduced considerably in width. The cutting edge will be wavy, the knife being wider at the point where there is no wear and narrower at the point of heavy wear. This makes for poor cutting on the lathe.

A straight cutting edge is of paramount importance if quality veneer of even thickness is to be cut. Today, many operations in the field are equipped with new heavy grinders which if properly maintained produce a good straight cutting edge.

It is important that the grinderman use an infeed on his grinding wheel that will be sufficient to break out of the grinding wheel those grinding particles which have become dull in the sharpening of the veneer knife. If feed is not continuous, the dull grinding particles stay in the wheel. If allowed to remain in the wheel, they begin to burnish the bevel of the knife and overheat it, either drawing the temper of the cutting edge or burning it. This often results in extremely smooth bevels on veneer knives which indicate a burnished condition with possible damage to the cutting edge.

Another point to remember in the resharpening of a veneer knife is not to use too heavy a feed in the sharpening process, because it will produce a thick wire along the cutting edge. Such a wire is one of the best indications of a dull ground knife. In contrast, a thin wire indicates a sharp cutting edge. When one contends with the problem of removing a heavy wire by honing, it will be realized that the

[1] Presented at Session XIV, Veneer and Plywood, FPRS Tenth National Meeting, June 4–7, 1956, at Asheville, N. C.

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thickness of this wire is actually a measure of the sharpness of the knife itself. The thicker the wire, the duller the cutting edge.

In the resharpening of any knife, the angle of bevel which is used to produce the cutting edge and the concave in that bevel must be considered. The pitch that is set in most lathes is changed only in very minor amounts by the operator. Any radical change in the bevel angle as ground will require a major adjustment in the lathe to correct the pitch. It is therefore very important that the grinderman make certain that he is resharpening his veneer knife at the same angle as it came to him from the lathe.

Closely connected with this angle of bevel is the amount of concave. Concave is measured by the space under a straight edge placed at right angles to the cutting edge and resting on the bevel of the knife. It is a false concept on the part of many operators to think that at least 1/16 inch or better of concave is a must to permit correct lathe operation. Actually the main reason for concave is to enable the grinderman and the operator to hone the knife between sharpenings without tipping the hone or having to work the entire surface of the bevel. Five thousandths or six thousandths of an inch in concave is ample for this honing operation.

Many lathemen figure the included angle of bevel on their knife by measuring the length of this bevel. If there is a heavy concave in the bevel, the actual angle will be much more acute than appears to be the case. This results in a weakened cutting edge.

The edge of a veneer knife when newly sharpened is extremely keen. During the first few hours of running, this edge must be watched carefully because it will be sensitive to knots and foreign material imbedded in the log until the knife becomes work-sharpened in the lathe. Work-sharpening produces a very minor bevel on that side of the knife towards the nose bar. Such a bevel strengthens the cutting edge.

In many West Coast operations, the lathe operator will run a file over the knife producing this bevel artificially and thereby provide a much stronger cutting edge at the beginning of the operation. Many a knife has been nicked because of a lack of knowledge on this point.

In setting a veneer knife in the lathe, damage will be done unless care is taken to be certain that the following rules are followed:

It is extremely important that the cutting edge of the knife be on a horizontal line with chuck centers of the lathe when in operation. If this is not done the automatic pitch adjustment will, when compensating for log diameter, throw the cutting edge out of position. This puts the edge either above or below chuck center to such an extent that it will tend to dive into the log or try to cut out. Slack in the chuck spindles, which allows the log to rise when rotating, will effect the position of the knife in its relationship to chuck center.

Most are familiar with the meaning of the term "pitch" as it refers to knife position in the lathe. Directly related to pitch is what might be called "knife bearing on the log." Too little bearing will result in considerable lathe chatter and washboard veneer. Too much bearing will force the lathe to labor, put heavy pressure on the cutting edge, and result in wavy veneer. Some operators err on the side of too much knife bearing because it has a tendency to smooth or compress the surface of the log just before the veneer is cut. Although the veneer appears smooth as it comes from the lathe, it will open up afterwards because this bearing puts the knife in such a position that it prys the veneer from the log.

The correct amount of bearing seen in good lathe operation helps to support the knife and makes it possible for the operator to control the thickness of the veneer he is cutting to very close tolerances. Correct bearing means that not only the machine, but the log as well, is helping to hold the knife in position.

There are other practices sometimes encountered in the field which may result in broken or bent knives. Quite often a lathe operator in rounding up his log will increase his infeed and throw back his pressure cap. Such a procedure will remove considerable knife support and allow the edge to weave in and out. This may break or bend a knife. Sometimes this operation is known as "slabbing."

We are all familiar with breakage due to a knife hitting the lathe chucks at either end of the log. This comes from the knife being run in too close to the lathe chucks at the finish of the operation.

Some operators, in an attempt to speed up the bolting or clamping of the knife onto the knife bar, will not pay adequate attention to make certain that the clamps are snug and flat against the knife or that all of the knife bolts are taken up. It is easy to understand why a knife will break if it is not securely held. The tremendous pressure exerted against the cutting edge will cause a knife to flex in the lathe unless it is rigidly supported.

Rubbers, or small pieces of wood that ride occasionally between the knife and the log, will bend a knife back unless removed. Shakes and pitch rings often found in softwood may cause severe damage to the knife and possibly to the lathe when they break loose from the log.

Hard knots have the following effect on the knife: Since the knife always strikes a knot at the same point, it has a tendency to dull the knife after several blows. The result is that the knife, being dull, tends to doge from the knot. The outcome may be either a bent knife or, in the opposite case, a broken knife if it dives into the knot in an attempt to regain its position.

Conclusions

Many of the points covered above are familiar to operators and yet not enough consideration is given to them in present-day operation. The increasing cost of making veneer should point out the extreme importance of continuous lathe operation. A broken knife or a bent knife means down time and poor utilization of the lathe crew. A poor grade of veneer is self-evident.

Discussion

Robert O. Larson (Larson Plywood Co.): When honing the face edge of a veneer knife, frequently during the run, is it advisable to follow this by honing lightly on the back edge of the knife to remove the fine wire edge, or should a wooden block be used? Our operator back hones lightly once or twice, with just the weight of the stone bearing at a very acute angle to the back of the knife. He claims this is preferable and the results seem to bear him out.

Mr. Bowditch: A wire edge on a veneer knife comes as a result of the sharpening of the knife in the grinding operation. In almost all instances, this wire is removed by honing in the grinding room and before being put into the lathe. Some people, while honing, use a wooden block to strip the wire from the knife. Others hold their hone at right angle to the cutting edge, allowing only the weight of the hone to rest on the cutting edge and strip the wire in this manner. When the wire has been stripped, two or three passes with the hone will bring it up sharp.

Many knives are honed in the lathe after they become dull or when they are nicked in a very minor fashion, to bring the edge back. It is perfectly permissible to hone on the two sides of the cutting edge while in the lathe but more of the honing should be done on the side opposite the bevel side. If a hone is tipped up on the bevel side to any great extent while honing, the pitch of the knife is changed at that point. Any change in pitch will affect the quality of the veneer cut.

Some Experimental Designs Applicable to Problems with Wood[1]

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Experiments to compare two or more treatments can be improved by use of blocking designs which balance out extraneous sources of error. If only part of the treatments can be arranged within each block, the design is known as an "incomplete block design". An example of the use of this arrangement is discussed in detail in connection with an experiment to investigate the influence of water and air temperature on the standard cyclic exposure test for plywood delamination.

Introduction

RANDOM VARIATION among experimental results is due in part to inherent differences in the raw material units used in the experimentation and also to the experimenter's inability to reproduce exactly the same environmental conditions and testing technique for each test result. Efforts to improve precision of comparative experiments fall into one of four general categories:

1. The experimenter may attempt to improve his measuring technique through the use of better physical apparatus, more carefully controlled environment, etc.

2. The experimenter may test each "treatment" a large number of times so that the random variations tend to "average out."

3. The experimenter may take measurements on auxiliary variables and use these to "adjust" the values of the principal variable. For example, the specific gravity of each specimen might be a useful auxiliary variable when strength properties of wood are under investigation.

4. A fourth general method for improving precision is the principle of "blocking" or arranging the experiment so that certain sources of error are balanced out of the treatment comparisons. Systems for achieving such blocking form the main subject matter of an important area of statistics known as the *design of experiments*. These designs have long been used in agro-biological experimentation and are now being found extremely useful in industrial research.

[1] Presented at Session I, Quality Control, FPRS Twenty-Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: R. J. Hader received B. S. from U. of Chicago, Ph. D. from N. C. State College, was a statistician at Los Alamos Scientific Laboratory before accepting his present position.

Randomized Block Designs

The simplest scheme for balancing out extraneous variation is the randomized block design. The experimental material is split up into groups or blocks within which the inherent random variation is expected to be small compared to that from one block to another. The treatments are then assigned to the raw material so that each treatment is represented once in each block. Any two treatments may then be compared on a within-block basis with information on the comparison pooled from the several blocks.

The important thing is that between-block differences in no way influence the desired comparison. For example, suppose an experimenter wishes to compare drying rates for veneer at four different drying temperatures. Six-inch square specimens are required. Blocking may be accomplished by working with groups of four specimens contiguous on the large sheet of veneer from which the test specimens are cut. One specimen of each such group is assigned to each of the drying temperatures. Presumably the inherent random variation among specimens will be smaller within the groups of four than across the whole large sheet.

In another example an experimenter may wish to test five modifications in the technique of shear testing glued blocks. He glues a number of billets, each of which is subsequently cut into five shear test specimens. The five specimens are then assigned to the five treatments and the treatments thus compared on a within-billet basis. Variations in glue spread, grain structure, pressure, etc. from billet to billet in no way affect the desired comparisons.

The success of these blocking arrangements, of course, depends on the experimenter's ability to group his raw material in such a way that the largest variation is between groups and the smallest within groups.

Incomplete Block Designs

The randomized block design described above is the simplest but most widely useful design. Many other useful arrangements are available. One extension is to incomplete block designs. It often happens that the natural groups or blocks contain fewer units than the number of treatments to be compared. In an experiment which the author recently helped plan, nine lacquers were to be compared for resistance to checking under an alternating hot-cold cycling (5). The lacquers were coated on plywood panels, each panel taking at most two different lacquers. A *balanced incomplete block design* was used, each possible pair of lacquers appearing together on the same panel once. To do this required 36 panels. Each lacquer appeared on eight different panels. Comparisons of any two lacquers could always be made on a within-panel basis. To pick up all of the information on a comparison of any two given lacquers, it was necessary to use the others as go-betweens. Systematic analyses are available for each of these designs.

Example: Plywood Delamination Test

The remainder of this paper will describe in some detail an experiment in which an incomplete block design was used to test variations in air and water temperature in the standard plywood delamination test (1).[2] Standards generally accepted by the industry for this test specify only that water be at room temperature and that drying temperature be between 70° F. and 100° F. In an investigation conducted at N. C. State College, C. A. Hart (4) made extensive tests under carefully controlled water and air temperatures. Four different cycling treatments were used:

[2] Numbers in parentheses refer to literature cited.

70/70: 70° F. Water, 70° F. Air
70/95: 70° F. Water, 95° F. Air
95/70: 95° F. Water, 70° F. Air
95/95: 95° F. Water, 95° F. Air

Comparisons among these treatments permit the evaluation of the effects of air temperature at both levels of water temperature and, vice versa, of the effect of water temperature at both levels of air temperature. The joint effect of raising both water and air temperature is also available.

Test specimens (6 by 6 inch) were cut from 13- by 26-inch three-ply panels with 1/16-inch rotary cut red gum veneer facing and core. Two 13- by 26-inch panels were glued (liquid urea-formaldehyde resin) and pressed together. A typical assignment of the treatment combinations to the eight 6- by 6-inch squares in each of these panels is shown in Fig. 1.

In order to improve precision, it was decided to compare the delamination results (number of cycles before failure) on *matched edges* of the 6- by 6-inch specimens. These edges, being separated physically by only the width of the saw kerf, could be expected to have very little inherent random variation, at least insofar as the experimental material is concerned. Only edges parallel to the face grain were used in this portion of the experiment.

The arrangement of Fig. 1 is an incomplete block design. Matched edges form the basic blocks. It will be noted that the comparisons 70/70 vs. 70/95, 95/70 vs. 95/95, 70/95 vs 95/95, and 70/70 vs. 95/70 each occur three times in the two panels shown. Actually the experiment could have been designed to include the remaining two possible comparisons, 70/70 vs. 95/95 and 70/95 vs. 95/70, with no loss in precision on the four comparisons actually used. It was decided, however, to concentrate on the comparisons which show separately the effects of changing the water and air temperatures.

In Fig. 1 the numbers shown in parentheses represent the observations (i.e., the number of cycles before delamination). It was felt that the changes in water and/or air temperatures would be more likely to produce proportional effects rather than constant effects, that is, for example, the *ratio* of number of cycles under 70/70 to number of cycles under 95/70 is probably a relatively stable quantity over a wide range of glue bond quality whereas this is not likely to be the case for the *difference* between the two treatments. When proportional effects are anticipated, an analysis of the logarithms of the observations is in order. At the conclusion of the analysis, the average differences on the logarithmic scale are readily converted into ratios.

Table 1 shows the common logs of the original observation. The two numbers in each row of the table represent the observations from the same block (matched edges). At the foot of each column is given the treatment total which could, of course, be immediately converted to an average. These averages, however, are not directly comparable as the block effects (glue line qualities) are not represented equally in each. The block effects would therefore not be balanced out of the comparison. This apparent difficulty is readily overcome as will be illustrated for the comparison of 70/70 vs. 70/95.

A simple estimate of the differential effect of these two treatments is furnished by confining our attention to Blocks 1, 2, and 3. From these three blocks, the average difference is .4733. This estimate is balanced for B–7255—Forest Products Galley 107 block effects but does not use all of the available information in the data.

Another completely independent estimate of the same effect can be obtained by:

$$(70/70 - 95/70)_{10\text{-}11\text{-}12} + (95/70 - 95/95)_{4\text{-}5\text{-}6} + (95/95 - 70/95)_{7\text{-}8\text{-}9}$$
$$.6433 + .1833 + (-.2900) = .5366$$

The subscripts on the parentheses indicate the blocks in which the difference is taken. This second estimate essentially uses the other two treatments as links in a chain connecting 70/70 and 70/95. In each parentheses the block effects are subtracted out so that the estimate .5366 is not influenced by block differences.

A weighted average of these two estimates is now in order. The appropriate weights are 3 and 1 because three times as many residual random errors contribute to the second estimate as to the first. The weighted average is therefore:

$$(70/70 - 70/95) = \frac{(3)\ (.4733) + (1)\ (.5366)}{3 + 1} = .4891$$

Similarly we can find estimates of the other treatment comparisons of interest:

$$(70/70 - 95/70) = \frac{(3)\ (.6433) + (1)\ (.5800)}{3 + 1} = .6275$$

$$(70/95 - 95/95) = \frac{(3)\ (.2900) + (1)\ (.3533)}{3 + 1} = .3058$$

$$(95/70 - 95/95) = \frac{(3)\ (.1833) + (1)\ (.1200)}{3 + 1} = .1675$$

These estimated average differences in the logarithms are converted to ratios of numbers of cycles by taking the anti-logs. Thus the ratio of 70/70 results over 70/95 is estimated to be 3.08, of 70/70 results over 95/70 is 4.24, of 70/95 over 95/95 is 2.02, and of 95/70 over 95/95 is 1.47. It is obvious that water and air temperatures must be specified within a much narrower range in order for the delamination test to yield reliable results.

There remains the assessment of precision for the average differences found above. Though block effects have been balanced out, there still exists some residual random variation. A measure of this error is available as follows: The 70/70 — 70/95 difference can be estimated separately within Blocks 1, 2, and 3. These values are $d_1 = .40$, $d_2 = .43$, $d_3 = .59$. Since these three values estimate the same quantity, the extent to which they differ is a reflection of the residual random error.

From these differences we calculate the variance (square of the standard deviation to be $s_d^2 = .010433$. Since the variance of a difference is twice that of a single observation we get $s^2 = .005216$. Similarly, the three 95/70 — 95/95 differences in Blocks 4, 5, and 6 produce a second estimate $s^2 = .001316$. The three differences 70/95 — 95/95 in Blocks 7, 8 and 9 yield a third estimate $s^2 = .000350$. The last three blocks yield a fourth estimate $s^2 = .036466$. A fifth and somewhat less obvious estimate of s^2 is available by taking $d_1 + d_2 + d_3 - d_4 - d_5 - d_6 + d_7 + d_8 + d_9 - d_{10} - d_{11} - d_{12} = -.19$. Careful consideration will show that this number is the result of pure random error. Its square divided by (2) (12) is the fifth estimate $s^2 = .001504$. The first four estimates have two degrees of freedom, the fifth has one. The appropriate average is therefore:

$$s^2 = \frac{1}{9}[(2)\ (.005216) + 2\ (.001316 + 2\ (.00350) + 2\ (.036466) + (.001504)\ ] = .0098.$$

This value represents an estimate of the random variation that would be present between the two observations on the matched edges if they were both subjected to the same treatment.

In simple completely randomized experiments and in randomized complete block designs, the variance of the difference between two treatment averages is:

$$s^2_{\bar{x}_1 - \bar{x}_2} = \frac{2s^2}{r}$$

70/95	95/70	70/95	70/70
(26)	(21)	(11)	(30)
(66)	(12)	(6)	(13)
70/70	95/95	95/95	95/70
(86)	(15)	(12)	(19)
(32)	(21)	(24)	(85)
70/95	95/70	70/95	70/70
(66)	(39)	(29)	(214)
(259)	(26)	(14)	(25)
70/70	95/95	95/95	95/70

Panel A Panel B

Fig 1.—Assignment of treatments to experimental units (Pressload No. 16).

where r is the number of replications of each treatment. For incomplete block designs the corresponding formula can be written as:

$$s^2_{\bar{x}_1 - \bar{x}_2} = \frac{2s^2}{rE_f}$$

E_f is called an efficiency factor because rE_f is essentially the *effective replication* in an incomplete block design. In our experiment $E_f = 2/3$ so that the variance of the difference between two treatment averages is

$$s^2_{\bar{x}_1 - \bar{x}_2} = \frac{2s^2}{(6)\ 2/3} = s^2\ 1/2 =$$

$$(.0098)\ (1/2) = .0049$$

whence $s^2_{\bar{x}_1 - \bar{x}_2} = .07$.

Standard 95% confidence intervals may now be attached to each of the treatment differences using students' t value with 9 degrees of freedom. The results are shown in Table 2.

Further Results

The data of Table 1 actually constitute only a small portion of the complete experiment. In all, twenty such pressloads were run. Pressload No. 16 was selected to illustrate the design and analysis. The analysis of all of the data gave the results shown in Table 3. The confidence limits given in Table 3 are based on a pooled estimate of the residual variance of $s^2 = .008233$ with 180 degrees of freedom.

In order to assess the effectiveness of the use of matched edges, two other variances were calculated:

(a) Using differences between edges receiving the same treatment but separated by 6 inches, it was found that the error variance would be approximately $s^2 = .0206$.

(b) Using differences between edges receiving the same treatment but separated by 12 inches (or slightly more), it was found that the error variance would be approximately $s^2 = .0423$.

It is evident that the use of matched edges results in a considerable reduction in error variance. Some of this reduction is offset by the loss in effective replication, i.e., by the factor $E_f = 2/3$. However, even taking this into account, it appears that using matched edges yields estimates of the average differences as reliable as would otherwise be obtained with from 50 to possibly 200 per cent more test specimens.

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3. Davies, O. L. (Editor). 1954. The design and analysis of industrial experiments. Oliver and Boyd, London.
4. Hart, C. A. 1956. Effect of temperature variation on the results of the cyclic exposure test for glue bond durability. For. Prod. Jour. VI (7): 247–251.

Table 1.—LOGARITHMS OF NUMBER OF CYCLES (PRESSLOAD NO. 16)

Block	70/70	70/95	95/70	95/95	Block Totals
1	1.82	1.42	...	...	3.24
2	1.93	1.50	----	----	3.43
3	2.41	1.82	...	...	4.23
4	...	...	1.32	1.08	2.40
5	...	...	1.32	1.18	2.50
6	...	...	1.59	1.42	3.01
7	...	1.04	...	.78	1.82
8	...	1.38	...	1.08	2.46
9	...	1.46	...	1.15	2.61
10	1.48	...	1.11	...	2.59
11	1.93	...	1.28	...	3.21
12	2.31	...	1.40	...	3.71
Totals	11.88	8.62	8.02	6.69	35.21

5. Schrumpf, W. J., Carter, Roy M., and Hader, R. J., 1956. A rapid method of evaluating check resistance of furniture lacquer films. Federation of Paint and Varnish Production Clubs, Official Digest.

Discussion

George Marra (Washington State Institute of Technology): Explain the necessity for logarithmic transformation.

Mr. Hader: The log transformation is used for data in which the effect of changing treatments is to increase or decrease the result by a constant *ratio,* rather than by a constant *absolute amount.* Working on a scale on which the effects are additive makes the analysis simpler and more efficient.

James R. Roberts (Weyerhaeuser Timber Co.): Why was there variation in the number of cycles in supposedly identical treatments even though a 6-inch separation exists?

Mr. Hader: Random variation in the data for supposedly identical treatments could be caused by minor variations in glue spread, grain structure, etc. Using matched edges gets around most of this variation and would do so even if the experimenter had been less careful in making his larger panels. Only the variation in glue bond quality existing across the width of a saw kerf is of concern.

Table 2.—SUMMARY OF ESTIMATES AND CONFIDENCE LIMITS

Treatment Comparison	Best Estimate	95% Conf. Limits	Anti-log Lower Limit	Anti-log Best Estimate	Anti-log Upper Limit
70/70-70/95	.4891	±.1583	2.14	3.08	4.44
70/70-95/70	.6275	±.1583	2.95	4.24	6.11
70/95-95/95	.3058	±.1583	1.40	2.02	2.91
95/70-95/95	.1675	±.1583	1.02	1.47	2.12

Table 3.—ESTIMATES AND CONFIDENCE LIMITS FOR COMPLETE EXPERIMENT

Treatment Comparison	Best Estimate	95% Conf. Limits	Anti-log Lower Limit	Anti-log Best Estimate	Anti-log Upper Limit
70/70-70/95	.4353	±.0283	2.55	2.73	2.91
70/70-95/70	.6309	±.0283	4.00	4.27	4.56
70/95-95/95	.3441	±.0283	2.07	2.21	2.36
95/70-95/95	.1485	±.0283	1.32	1.41	1.50

An Investigation into the Effects of Certain Variables in Scarf-Jointed Timber Laminations[1,2]

SELWYN P. FOX

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A total of 950 Douglas-fir specimens were tested in tension parallel to the grain. Objectives were to evaluate the strength ratio of various scarf joints, to investigate the influence of "notch effect" on these strength ratios, and to determine whether strength ratio varied with the use of more than one adhesive in bonding comparable joints.

Part I: Introduction

DURING THE WINTER of 1953, 16 glulam (glued-laminated) beams were tested by the Forest Products Laboratory at Ottawa for the purpose of substantiating provisions of C.S.A. 0122–1953, Specification for Glued-Laminated Timber Construction. Results of these tests showed that the beams did not carry the load calculated by this specification (1) (4).[3]

Observation of the nature of the failures led to the surmise that the notch or step in a hooked-scarf joint was a stress-concentrating factor which reduced the modulus of rupture below that estimated by current specifications (4).

As a result of concern expressed by fabricators of glulam timber products, the Canadian Institute of Timber Construction promoted and with the Ottawa FPL sponsored a testing program on scarf joints and various components of these joints.

In this investigation of scarf joints and notch effect, the writer has studied four related experiments on Douglas-fir wood. They include the following: the effect of change in cross-sectional area upon the tension parallel-to-grain strength of scarf-jointed and unjointed specimens, the strength ratios and other properties of scarf joints of different dimension, the effect upon the tension parallel-to-grain strength of the removal of the end steps of a hooked-scarf joint, and the effect of notching on the tension parallel-to-grain strength of unjointed clear specimens.

In order to be as close as possible to the laminating conditions met in practice, the scarf joint specimens were fabricated by commercial methods.

Part II: Tensile Tests of Scarf Joints of Two Cross-Sectional Areas (5)

Introduction: Much work has been done to date in various laboratories on the tension parallel-to-grain strength of wood. The chief problem has been to obtain a specimen design that will fail invariably in tension in the test section rather than in shear at the point of load application.

The U. S. Forest Products Laboratory released a report in 1951 illustrating a new tension parallel to the grain specimen designed to fail by tension in the test section. A comparison was made between the new design and the standard in use which indicated that the new specimen's smaller cross-section provided average tensile strength values differing by a value of less than 1 per cent. The standard deviation of the stress at maximum load was smaller with the new specimen (6).

Although it would appear that there is no significant change in strength values with change in specimen cross-section, it was proposed to test larger sections of less selected stock and also to test scarf joints of two different cross-sectional areas.

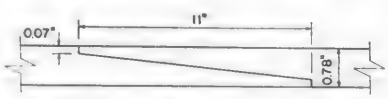


Fig. 1.—SC and SR scarf joint dimensions.

Purpose: The purpose of this test was to determine any significant change in tensile strength values of scarf-jointed and unjointed specimens when the test section is reduced in cross-sectional area from approximately 0.87 square inches to 0.49 square inches.

Materials and Construction: Twenty unjointed and 40 matched scarf-jointed specimens were tested in tension parallel to the grain. They were sawn plain-scarf joints of scarf slope 1:17 and with end steps of 0.007 inches (Fig. 1).

Fabrication before testing was in the following manner.

Twenty pieces of 1 in. by 8 in. by 6 ft. Douglas-fir, Coast Region, Laminating Grade B with no knots, were taken and marked with code letters which have the following meanings:

first letter	S—plain-scarf joint, sawn
second letter	C—casein glue
	R—waterproof adhesive
number	—number of the specimen
third letter	A—specimen of nominal cross-section of 0.87 sq. in.
	B—specimen of nominal cross-section of 0.49 sq. in.
	C—unjointed control specimen.

For example, SR2A indicates the second sawn plain-scarf joint bonded with waterproof adhesive and having a cross-section of about 0.87 square inches.

These 20 pieces were ripped into three equal parts. The center pieces or controls were set aside ready for shipment and the remaining 40 pieces were cross-cut at their centers, scarfed at these cross-cut ends, and reassembled and bonded to form 20 pairs of matched scarf joints. The 60 specimens were then packaged and shipped to the Laboratory.

The word "matched" may require further explanation. To form a matched specimen a board is cross-cut at its center and these two adjacent ends are scarfed in such a manner that the board when reassembled is exactly as before except for a parallelepiped shaped piece of wood of approximately the length of the scarf joint which is cut away by scarfing.

[1] Winning paper in 1956 Wood and Wood Products Award, sponsored by Vance Publishing Co., Chicago. Paper presented at Session VI, Glues and Gluing, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] Condensation of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Applied Science in Timber Engineering, University of Toronto.

[3] Numbers in parentheses refer to literature cited.

The Author: S. P. Fox holds B. A. Sc. from U. of British Columbia, M. A. Sc. from U. of Toronto. From 1952–54, he was assistant logging engineer at Renfrew Logging Division, British Columbia Forest Products, Ltd. During the summer of 1955, he was a technical officer at Forest Products Laboratory, Ottawa. He accepted his present post upon graduation from U. of Toronto this year.

Procedure: On receipt of the specimens, slope of grain measurements were made of each half of a joint and at the center of the corresponding control. The specimens were then trimmed to equal width and length and were reduced in section by bandsaw and spindle shaper.

Loading blocks were glued onto the ends of the specimens as in Fig. 2, and were squared afterwards for equal loading distribution by the universal testing machine.

The specimens were then conditioned to approximately 10.5 per cent moisture content and at the time of testing the reduced section was measured to 0.001 inches. The loading rate used with the testing machine was 0.05 inches per minute and the maximum load as well as the type and location of failure were recorded on data sheets. Where failure occurred in the jointed specimens along the glue line, the percentage wood failure was estimated according to regular laboratory procedure.

From the shaped section, a small sample was cut for moisture content and nominal specific gravity measurements. Nominal specific gravity may be roughly defined as the ratio of the oven-dry weight to the volume at the time of testing.

Moisture Content Adjustment of Strength Values: In Progress Report No. 1 of Project 0–240–3 filed at the Ottawa FPL Library, strength values determined at various moisture contents were adjusted to a common moisture content value but with words of reservation.

Calculations made for subsequent progress reports showed that the adjustment did not decrease the coefficient of variation nor change any strength values significantly. As a result of this strength-moisture content study, the test data were examined using the results of tests with moisture content as at test.

Data Used in Computations: Some specimens were not considered desirable for inclusion in calculations for one of these reasons: either the specimen was incapable of being tested; or since the calculations were made chiefly for comparative purposes, the writer felt that knots causing failure and torn grain causing failure played more than their share in the destruction of the specimen.

Failures in the reduced section were considered to be more representative of the results desired for this investigation of scarf joints. Inclusion of other specimens tends to produce either conservative or liberal values depending on the calculation under consideration. For this reason all calculations were based upon specimens that failed in the reduced section only. Table 6 includes statistical figures derived from these specimens.

Fig. 2.—Typical unjointed specimen.

A comparison of values indicates that the greatest change brought about by exclusion of failures outside the reduced section is found in the unjointed or control values. Many of the values excluded failed in longitudinal shear in the scab area which would indicate that the reduced section was too great in cross-sectional area.

Discussion of Results: The data were subjected to an analysis of variance test which, at a 5 per cent confidence level, showed no significant difference between the two sets of scarf joints and between the two sets of controls of the two cross-sections used in testing.

Further "t" tests with the same level of confidence indicated, however, that there was a difference between strength values of the casein glue joints and the waterproof adhesive joints. The average strength of the casein joints was 6043 psi and that of the waterproof 4879 psi. The "t" test indicated no difference between the controls of the two types of glue joints but since the average strength of the waterproof controls (10729 psi) was lower than that of the casein controls (13281 psi), the strength ratio values of the two glue joints were equal and were 0.455.

Furthermore, since these joints were matched ones, it can be expected that random assembly of end joints would produce a weaker joint. What difference there might be cannot be estimated by this experiment. Also it must be understood that these joints were pre-assembled, which is typical of laminations made up for the assembly of curved glulam products.

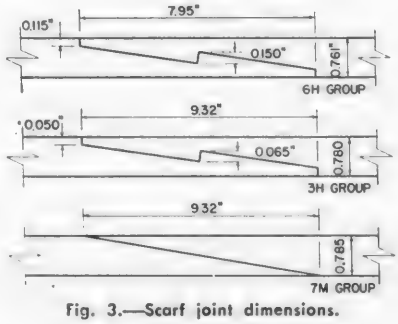


Fig. 3.—Scarf joint dimensions.

Conclusions and Observations: Since the tests outlined in this Part indicate no effect on strength because of change in specimen cross-section, and since it was imperative that all specimens fail in the reduced section, the writer decided that in future tests the scarf-jointed specimens would be shaped to a cross-section of about 0.87 square inches and the control (unjointed) specimens would be shaped to a cross-section of about 0.49 square inches.

It was observed that the end step of the scarf appeared to contribute materially to the failure of the specimens in that the failure surfaces in most instances passed through one or both end steps.

Part III: Scarf Joint Tests Conducted at Ottawa (5)

Introduction: Estimates of the strength of scarf joints have been based upon the work of the U.S. FPL (2), and since the scarf joints prepared and tested by that Laboratory were perhaps more ideal than factory-produced joints, there has been hesitation among Canadian fabricators to apply these laboratory results to the design of their products.

C.S.A. 0122–1953, paragraphs 76 and 78, (see Appendix), indicates the present working stresses used for scarf joints of the plain and hooked types.

As far as can be learned, the hooked-scarf joint has never been investigated in Canada or the United States, and although it has fabricating advantages over the plain-scarf joint, investigation of its real strength as compared to its theoretical strength is extremely important for engineered design of glulam products.

In this investigation, the Ottawa Laboratory tested three types of scarf joint: one plain-scarf and two hooked-scarf joints. The dimensions of these joints are illustrated in Fig. 3. One other hooked-scarf joint was tested by the Laboratory and the results of this work are reported in Part IV.

Purpose: The general objective of this investigation was to determine the relative strength ratios of various types of pre-assembled scarf joints of scarf slope 1:12 when subjected to failure by tension parallel-to-grain loading.

The specific objectives included:

1. To find the effect of the three machined steps in hooked-scarf

Fig. 4.—Hooked-scarf casein unmatched specimens.

joints on the strength ratio values of scarf joints;

2. To determine whether or not strength values differ due to the use of casein glue and resorcinol adhesive in comparable joints.

Materials and Construction: Four shipments of specimens were received at the Ottawa FPL and were inspected for compliance with the specifications supplied to the fabricators. Half of one shipment was found to be incorrectly fabricated and these were employed to advantage in the work of Part VII. This shipment was replaced with correctly fabricated specimens.

An explanation of the specimen identification used throughout this and other Parts is:

first number—for identification of shipment

first letter
- H—hooked scarf, machined
- M—plain scarf, machined
- S—plain scarf, sawn

second letter
- C—casein glue
- R—waterproof or water-resistant adhesive

third letter
- M—matched joint
- U—unmatched joint
- C—control specimen (unjointed)

final number 1 to 20—each 20 pieces in a specimen group are consecutively numbered 1 to 20.

Fig. 5.—Transverse tension at reduced section.

Upon receipt of the specimens, the Laboratory cut them to uniform dimensions, reduced the test section with bandsaw and spindle shaper and applied scabs (with casein glue, nails, and clamps) to the specimen ends as shoulders for load application. The specimens were then conditioned to about 12 per cent moisture content. The loading rate, reduced section measurements, recorded information, and observations were as described in Part II. Fig. 4 illustrates a set of typical scarf-jointed failures.

Tests of the following specimens are reported in this Part: 3HCC 1–20, 3HRC 1–19, 6HRC 1–20, 7MCC 1–20, 3HCU 1–20, 3HRU 1–19, 6HRU 1–20, 7MCU 1–20.

Data Used in Computations: For the same reasons given under this heading in Part II, all calculations were based upon specimens that failed in the reduced section.

Results and Discussion of Results: Since further scarf-joint data are presented in Parts IV and V, the results of these three Parts will be consolidated and discussed in Part VI. The statistical values are presented in Table 6 by shipment number.

Type and Location of Failure: British Commonwealth Forest Terminology defines "brittle" as "a fracture having the appearance of a broken crisp carrot which occurs in bending and tension tests; sometimes referred to as 'carroty' failure." They also define "brash, brashness, and brashy" as "a term used to denote the characteristic of timber which breaks with a short fracture: i.e., with little or no splintering. Synonym — short grain."

The preceding paragraph would serve as an introduction to a complex subject: the identification of the type of failure which occurred in tension parallel-to-grain tests of Douglas-fir. The Vancouver Forest Products Laboratory had this comment to make:

> "The common type of failure in tension parallel to the grain is a square break. At one time we were describing this type of failure as brashness, but when it was indicated in other tests that there was no brashness in many of the associated pieces from the same log, we began to think that the kind of splintering tension which is associated with other tests, though not characteristic of this test, may be indicated by the square break. At any rate we feel it is a type of failure which should be specifically described.
>
> "We cannot, therefore, give you descriptions of a range of typical failures in this test, as these failures almost invariably took the form of square breaks. That this is a type of failure associated with the kind of test rather than the species of wood is borne out by the fact that we have observed similar failures in other species."

Upon receipt of this comment, the writer decided to use the word "transverse" to describe failures that were wholly or in part like the fractures of Figs. 5 and 6. Note that Fig. 6 is of wood identified as compression-wood and, therefore, might be brash wood in the true sense of the word. Fig. 5 illustrates a failure typical of many specimens and would appear to be as in Fig. 6 except that small protruding fibres of summerwood are often present.

Fig. 7 is illustrative of the other types of failure observed in tests of the control specimens.

One other failure was common with the scarf-jointed specimens and that was "tension along the scarf." The words "shallow" and "deep" were used to modify this phrase which means, in effect, failure along the glue line with a percentage of wood failure estimated as well. "Shallow" implies

Fig. 6—Transverse tension at reduced section —compression wood.

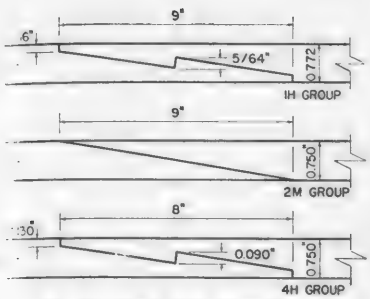


Fig. 8.—Scarf joint dimensions.

that actual glue line is in evidence and "deep" implies that little or no glue line is seen but that the failure occurred along a line parallel to the glue line.

In correspondence with the writer, the Ottawa Laboratory defined "deep" and "shallow" wood failure as follows:

> "A 'deep' wood failure is one where considerable wood has been pulled away with the glue line and failure extends to such a depth as to expose a clean wood surface with no evidence of glue or glue stains. In such cases, there is no difficulty in assessing the percentage wood failure.
>
> "A 'shallow' wood failure is one where failure occurs very close to the glue line. This type of failure is very deceiving because the glue line is in evidence and one is liable to consider such areas as complete glue failure. However, a very close examination will show a very thin layer of wood fibre adhering to the glue line. This results in the broken glue line having a 'fuzzy appearance.' This thin layer of wood fibre is noticeable under a magnifying lens and will be seen quite clearly when examined under a microscope using a magnification of approximately 50 diameters. Such examination will show that the wood fibres on the surface of the glue line lie at an angle to the fibres beneath the glue line. This indicates that these fibres have been transferred with the glue line from the opposite contacting wood surface. As previously stated, we recognize this condition as indicating wood failure."

Actual Grain Slope: According to project specifications, the Laboratory received Laminating Grade B material which is defined by C.S.A. 0122–1953 specification to have a slope of grain not steeper than 1:15. All specimens received were found to be within this specification but only when the edge of the board was inspected.

Slope of grain on the wide face of flat-sawn lumber is defined by determination of the fiber direction or resin canal direction where the latter can be seen.

Fig. 7.—Typical failures seen in tests. Top specimen: transverse tension at reduced section; second specimen: transverse tension at reduced section—compression wood; third specimen: simple tension at reduced section; fourth specimen: splintering tension at reduced section; bottom specimen: cross-grain tension at reduced section.

The preceding comments are made to bring to the reader's attention that steeper than 1:15 slope of grain is found in Laminating Grade B lumber and that this steep grain is often the cause of failure of specimens tested in tension approximately parallel-to-grain.

Part IV: Further Scarf-Joint Tests Conducted at Ottawa (5)

At the Ottawa FPL during the fall months of 1955, 120 specimens were tested as a continuation of the testing program described in Part III.

These specimens were of the hooked-scarf type and are identified by the number 4. They consisted of 40 specimens bonded with casein glue, 40 specimens bonded with resorcinol adhesive, and 40 unjointed control specimens.

Since the writer did not conduct the testing of this shipment, only the statistical values computed from the test are presented and may be found in Table 6.

The purpose of these tests, the materials used, and the construction of the specimens are as described in Part III. The dimensions of this joint are illustrated in Fig. 8.

Part V: Scarf Joint Tests Conducted at Toronto

At the University of Toronto during March and April of 1955, 270 specimens were tested by C. C. Henderson and the writer.

The purpose, objectives, materials, and the construction of the specimens were the same as those reported in the previous Parts.

The study at Toronto consisted of two shipments of 120 specimens each. To correlate these data with the work at the Forest Products Laboratory, the shipments were numbered 1 and 2, and are referred to by these numbers in all conclusions and statistical tables. Shipment 1 represented a machined hooked-scarf joint; shipment 2 represented a machined plain-scarf joint with feathered edges. These are illustrated in Fig. 8.

The data and presentation of these results as well as conclusions were worked and written independently by C. C. Henderson and are found in his thesis, Strength Testing of Scarf-Jointed Timber Laminations (3).

A small special study was carried out on 30 control-type specimens from ten boards to investigate the variation in strength within an 8-inch board. Analysis showed that calculations based upon averages for a group of specimen values were less variable than those based upon individual values. The analysis indicated that the average difference between the middle strips and outer strips was not significant, and that the average strength of the middle strip provides a reasonable control for the outer strips (3).

Part VI: Consolidation of Scarf Joint Results

Introduction: This Part presents the results of the tests outlined in the previous three Parts and a comparison of these results. Statistical values may be found in Table 6. The comparisons are in the order of the objectives listed in Part III.

General Objective: To determine the relative strength ratio of various types of pre-assembled scarf joints of scarf slope 1:12 when subjected to

failure by tension parallel-to-grain loading.

A comparison of the strength ratios listed in Table 1 and the scarf joint dimensions of Figs. 3 and 8, will indicate the importance of the notch depth at the end of the joint. A graphical representation is presented in Part IX.

Strength ratio is defined as the ratio of the mean strength of the joint group to the mean strength of the respective control group.

The reader is reminded that the unmatched groups are ones in which the joint tested is made of different boards and therefore would represent the case of lumber selected for glulam construction, end-scarfed, and bonded into continuous laminations.

Objective 1: To find the effect of the three machined steps in hooked-scarf joints on the strength ratio values of scarf joints.

The U. S. Forest Products Laboratory determined that a scarf slope of 1:12 decreased the strength of clear wood about 10 per cent (2).

However, if 10 per cent is allowed for the scarf slope in the specimens tested in this study, any further decrease in average strength experienced by tests may be due to inadequate bonding, decrease due to the presence of the end step and hook, stress-raising factors, unmatched grain, or a combination of these.

Two assumptions will be made: first, since block shear tests of the scarf joint glue lines were not conducted, and also the estimated percentage wood failure figures appeared adequate, it will be assumed that bonding was adequate; second, since the specimens were made in various factories and the effect of different scarfing techniques is not known, it will be assumed that scarfing effect is equal in all specimen groups.

It remains for us to assume that values of specimen group 2M, a machined plain scarf with no end steps but feathered edges, are the ultimate in unmatched scarf joints. This joint has been estimated to have a strength ratio of about 0.85. The difference between this figure and 1.00 is attributed to a combination of the 1:12 scarf slope and the unmatched grain bonded together in the joint. Summerwood bonded to summerwood may be stronger than summerwood to springwood. The strength ratio of 0.90 of the U. S. Forest Products Laboratory tests is based upon specimens made by sawing at the desired 1:12 slope, planing these surfaces, and then bonding the faces together to produce essentially the same grain alignment as was present before sawing; i.e., summerwood to summerwood and springwood to springwood.

It is therefore proposed that shipment 2M be used as a basis of comparison. Table 2 presents the difference between the respective shipments and shipment 2M.

Objective 2: To determine whether or not strength values differ due to the use of casein glue and resorcinol adhesive in comparable joints.

With 1HRU, 2MRU, 3HRU, and 4HRU, resorcinol adhesive was used for bonding. Phenol-resorcinol was employed to bond joints in group SR.

The statistical values of the five groups in Table 3 were submitted to an analysis of variance "t" test which revealed no significant difference at a 5 per cent level of confidence between casein and resorcinal groups in four of the five shipments supplied in two adhesive types.

This particular study would indicate that in most cases, bonding with resorcinol adhesive is equal to bonding with casein glue.

Part VII: Tensile Tests of Modified Hooked-Scarf Joints (5)

Introduction: Laboratory work outlined in Parts II and III has indicated that the end step (or notch) may perform an important part in the reduction of the strength of the hooked-scarf joint.

In this experiment simple measures were taken with the specimens used and somewhat alarming results were achieved. These results confirmed the suspicions held about the effect of the end steps on the strength of laminations under tension.

Purpose: The object of this experiment was to determine the effect upon joint strength of removing the end steps of a hooked-scarf joint. The removal operation is effectively done by planing.

Materials and Construction: Twenty unjointed and 40 scarf-jointed specimens were delivered to the Laboratory but because of an error in fabricating the specimens, they were unsuitable for their original purpose.

Table 1.—SCARF JOINT DIMENSIONS AND STRENGTH RATIOS

Specimen Group	Scarf Joint Characteristics: Lam. Thickness, in.	Scarf Slope	End Step inches	Hook in.	Mean Strength psi	Strength Ratio
1HCC					11659	
1HCU	0.772	1:12	0.062	0.078	6132	0.53
1HRC					10709	
1HRU					5596	0.52
2MCC					10842	
2MCU	0.750	1:12	None	None	9692	0.89
2MRC					13513	
2MRU					10823	0.80
3HCC					12740	
3HCU	0.780	1:12	0.050	0.065	5670	0.44
3HRC					12240	
3HRU					6260	0.51
4HCC					11110	
4HCU	0.750	1:14	0.130	0.090	3820	0.34
4HRC					11940	
4HRU					3710	0.31
6HRC					12820	
6HRU	0.761	1:12	0.115	0.150	3740	0.29
7MCC					11910	
7MCU	0.785	1:12	0.022	None	8840	0.74

Scarf joint characteristics are the same for all specimens bearing the same specimen group number. Average strength values are calculated only from those specimens which failed in the region of the scarf joint: i.e., the reduced section.

Table 2.—COMPARISON OF HOOKED-SCARF JOINTS WITH A PLAIN-SCARF JOINT

Specimen Group	Scarf Joint Characteristics: Lam. Thickness, in.	Scarf Slope	End Step inches	Hook in.	Difference in Strength Ratio
1HCU	0.772	1:12	0.062	0.078	0.32
1HRU					0.33
2M	0.750	1:12	None	None	0.00
3HCU	0.780	1:12	0.050	0.065	0.41
3HRU					0.38
4HCU	0.750	1:14	0.130	0.090	0.51
4HRU					0.50
6HRU	0.761	1:12	0.115	0.150	0.39

Table 3.—COMPARISON OF MEAN TENSILE STRENGTHS

Specimen Group	No. in Group	Mean Tensile Strength psi	Coefficient of Variation %	Significant Difference (t.05)
1HCU	18	6132	15.1	
1HRU	19	5596	24.6	No
2MCU	19	9692	21.8	
2MRU	15	10823	22.0	No
3HCU	17	5670	19.5	
3HRU	18	6260	13.6	No
4HCU	19	3820	21.2	
4HRU	19	3710	16.2	No
SC	20	6043	17.6	
SR	19	4879	21.9	Yes

The planing operation reduced the specimen thickness about 0.14 inches and removed the end-step notch, thus leaving a smooth surface on the face of the lamination (Fig. 9). The remaining 20 specimens were not modified and represent a standard matched hooked-scarf joint (Part II).

The following specimens were tested and the results appear in Table 4.

Planed		Unplaned	
3HCA	1–10	3HCA	11–20
3HCB	11–20	3HCB	1–10
		3HCCX	1–20

Discussion of Results: A new type of failure was observed in many of the 20 planed specimens. This transverse type of failure occurred at the hook cross-section which is theoretically the weakest section of the joint.

In analysis of the joints tested, it was determined that planing of the specimens increased the average strength ratio of the joint. This increase is significant and is an indication of the extent to which the notch or end step is a stress raiser in the particular hooked-scarf joints tested.

According to C.S.A. 0122–1953 specification, the strength of the "planed" hooked-scarf joint should be about 0.9(0.9)(100) = 81 per cent of control strength when one considers a scarf slope of 1:12 and a cross-section reduced only by the sectional area of the hook.

Comparison of the calculated figure of 81 per cent and the test figure of 80 per cent (0.799) would suggest that the hook had little or no stress-raising effect. This fact remains to be proven.

Conclusions: It was suspected and confirmed that the end steps of the standard hooked-scarf joint have a great effect upon the tensile strength of laminations containing these joints. This experiment indicated that the planing operation carried out by the Laboratory increased the strength ratio rating of the specimens tested by 29 per cent and the tension parallel-to-grain strength by 58 per cent.

Part VIII: Tensile Tests of Notched Unjointed Laminations

Purpose and Scope of Tests: To provide more data on the effect of notching the face of single laminations, tests on clear, straight-grained Douglas-fir were run at the University of Toronto during November, 1955. The specimens numbered altogether approximately 120 and were divided into three groups of 40: controls; one notch on one face, centered; and two notches, one on each face, located nine inches apart. These latter two groups were subdivided into sets of 10, each of which was sawn to a notch depth of either 1/64, 1/16, 1/8, or 3/16 inches.

Objectives: The chief objective was to seek and evaluate a relationship between strength and notch depth, and to correlate these data with the scarf-joint tests.

Materials and Construction: The writer selected clear 1 in. by 8 in. S2S Douglas-fir of the straightest grain available. Six-foot lengths were cut and the boards marked with a letter and a number. The letters E, F, G, and H represent the respective depth of notch and the number indicates the particular specimen within the set of ten. Each of the three same letter-number combinations was from the same board and the three groups of 40 each were selected randomly and kept separate throughout the experiment.

All specimens were then trimmed to uniform length and width. Spindle shaping to a cross-section of ½ inch by ¾ inch followed and, with the use of a circular saw, notches were cut to depth as designated by specimen letter and located as in Fig. 10. The control specimens were unnotched but shaped to the same dimensions.

Douglas-fir scabs were cut and applied to the ends of the control specimens exactly as at the Forest Products Laboratory. Load application to the 80 notched specimens was applied by flat grips.

There were no moisture content conditioning facilities available and therefore the tension tests were run in as short a time period as possible. The loading rate was 0.05 inches per minute and the maximum load as well as the type and location of failure were recorded.

From the shaped section a small sample was cut for moisture content and specific gravity measurements.

Results: Results of these tests may be found in Table 7. In the calculation of the latter, as with the scarf joints, failures associated with knots or located outside the reduced section were excluded.

The average strength values of the four control groups, E, F, G, and H, were tested for significant difference and none was found at the 5 per cent level of confidence. The specimens were therefore all of the same population.

Strength ratio was calculated by use of the respective control averages and the graphs of Fig. 11 were produced.

The tensile strengths of the notched specimens were calculated using the gross area. To convert these values to ones based on net area, the factor h/(h–d) must be applied where h is the gross or overall depth of the specimen and d is the nominal depth of the notch.

The specimens with one notch, centered on one side, had factors of 1.02, 1.09, 1.19, and 1.32 (E, F, G, and H respectively) applied to their average strength values. When the resulting strength values are compared to the respective controls and the ratios

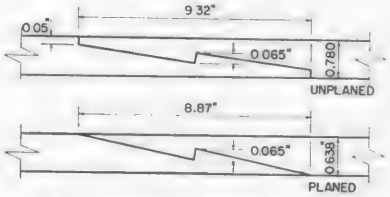


Fig. 9.—Modified hooked-scarf joint.

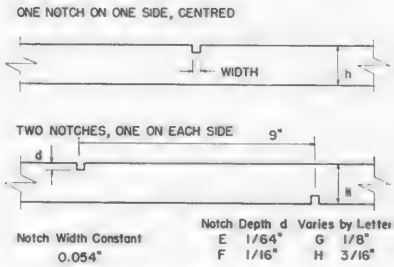


Fig. 10.—Location of notches.

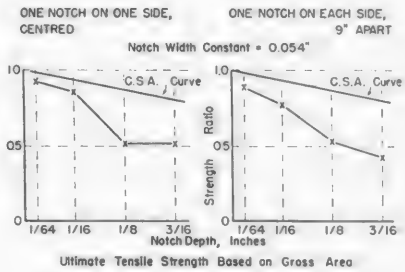


Fig. 11.—Variation of strength ratio with notch depth.

Table 4.—COMPARISON OF MODIFIED AND UNMODIFIED HOOKED-SCARF JOINTS

Specimen Group	No. in Group	Moisture Content % Avg.	Max.	Min.	Mean Tensile Strength psi	V %	Strength Ratio
3HC planed	17	11.2	13.2	9.5	9528	17.5	0.799
3HC unplaned	20	11.2	12.5	9.9	6016	19.5	0.505
Difference		0			3512		0.294

V = Coefficient of Variation — Reduced Section Failures Only

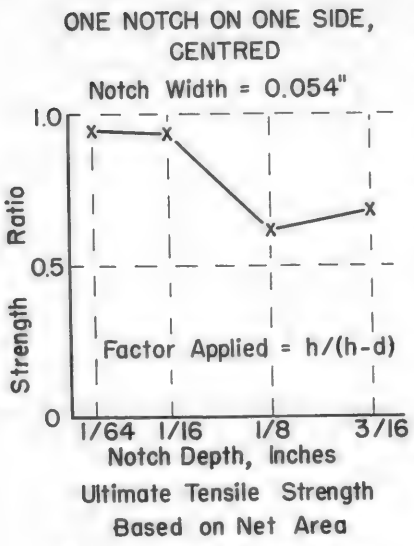


Fig. 12.—Variation of strength ratio with notch depth.

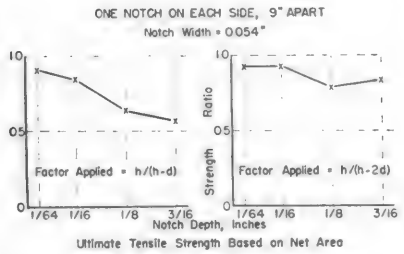

ONE NOTCH ON EACH SIDE, 9" APART
Notch Width = 0.054"
Factor Applied = h/(h-d)
Factor Applied = h/(h-2d)
Strength Ratio
1/64 1/16 1/8 3/16
Notch Depth, Inches
Ultimate Tensile Strength Based on Net Area

Fig. 13.—Variation of strength ratio with notch depth.

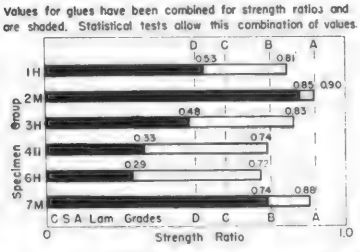

Values for glues have been combined for strength ratios and are shaded. Statistical tests allow this combination of values.
D C B A
1H 0.53 0.81
2M 0.85 0.90
3H 0.48 0.83
4H 0.33 0.74
6H 0.29 0.72
7M 0.74 0.88
Specimen Group
C.S.A. Lam. Grades D C B A
Strength Ratio
0
1.0

Fig. 14.—Histogram of strength ratios and C. S. A. theoretical strength ratios.

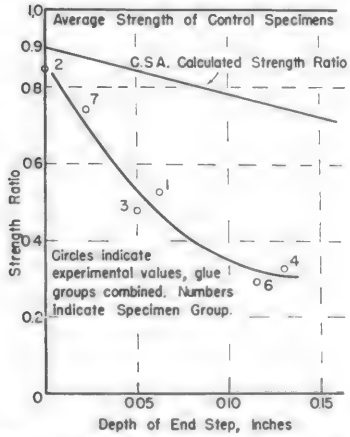


Fig. 15.—Variation of strength ratio of unmatched specimens with depth of end step.

are plotted against notch depth, the curve of Fig. 12 is derived. Any difference in ordinate between 1.00 and the curve for any particular notch depth is apparently due to stress-raising factors. The stress-concentrating factor of the notch seems to increase with depth of notch. Whether or not the notch width is influential has not been ascertained by the writer. It is a possibility.

Similar application of net area factors (h/(h–d) and h/(h–2d)) to mean strength values of the two-notch (one on each side, nine inches apart) specimens produces the curves of Fig. 13. As before, the difference in ordinate between 1.00 and the curve at any point is apparently due to stress-concentration. A comparison of the two latter curves with the former curve of Fig. 12 would indicate that with the two-notch specimens the correct net area factor lies between the two values used, i.e., between (h/(h–d) and (h/(h–2d).

Part IX: Conclusions of Studies

General: In this investigation of scarf joints and notch effect, the writer has studied four related experiments on Douglas fir-wood. They include: the effect of change in cross-sectional area upon the tension parallel-to-grain strength of scarf-jointed and unjointed specimens, the strength ratios and other properties of scarf joints of different dimension, the effect upon the tension parallel-to-grain strength of the removal of the end steps of a hooked-scarf joint, and the effect of notching on the tension parallel-to-grain strength of clear unjointed specimens. These experiments will be discussed separately and correlated where possible.

The Effect of Change in Cross-Sectional Area on Tensile Strength: This study, discussed in Part II, indicated that the change in cross-sectional area had no significant effect on the tension parallel-to-grain strength of scarf-jointed and unjointed wood. The notch effect of the end step of the scarf joint was noted and further experiments were planned to study this stress-concentrating factor.

Tensile Tests of Scarf Joints: A comparison of scarf joints tested is presented in the histogram of strength ratio and the corresponding C.S.A. 0122–1953 specification theoretical strength ratio of Fig. 14. The rated strength of Laminating Grades A, B, C, and D lumber is also shown to indicate the relation between the scarf joints tested and the various lumber grades in which they can be employed as end joints.

Provided that tension tests of single laminations are a criterion of laminating strength in beams and other structural members, it appears to be rather uneconomical to manufacture glued-laminated products with lumber which is stronger than the scarf joints employed to act as end connections in continuous laminations.

To present the results of these particular studies graphically, Fig. 15 has been drawn. Strength ratio and various combinations of joint dimensions were plotted and studied on a comparative basis. The most conservative and perhaps the most well related data curve was chosen to be presented in Fig. 15. Strength ratio has been plotted against the notch depth created by the end step. For each scarf joint the strength ratios of each of the two glue groups have been combined. This was found to be permissible by statistical tests of the data, i.e., there was found to be no significant difference between casein glue values and waterproof adhesive values for the same scarf joint. A non-linear trend is seen in the graph and for comparative purpose the straight-line decrease in strength ratio based on C.S.A. 0122–1953 is presented as well.

The reader will see at a glance that, providing the tension parallel-to-grain test of single laminations is a sufficient criterion of lamination strength, the current C.S.A. specification for working stresses of scarf-jointed laminations is inadequate. Further joint studies in laminated beams may indicate such inadequacy to be not as great as it would appear in Fig. 15.

Efficiency values are presented in Table 5 to show the relation between the strength of the scarf joints tested and the expected strength by C.S.A. 0122–1953 specifications and by a standard adopted here for comparative purposes. C.S.A. 0122–1953 is interpreted to say that only the greatest step in a scarf joint shall have its depth dimension substracted from the lamination thickness to determine the net section. The standard adopted here for comparative purposes is that all steps including the hook, if present, shall be summed and subtracted from the lamination thickness to determine the net section.

Efficiency may be defined as the strength ratio of the scarf joint expressed as a percentage of the expected

Table 5.—EFFICIENCIES OF SCARF JOINTS

Specimen Group	Efficiency by C. S. A. 0122-1953 specification	Efficiency by standard adopted for comparison
1H	65%	79%
2M	94	94
3H	58	67
4H	44	68
6HRU	40	65
7MCU	85	87

strength ratio determined by current C.S.A. specifications or by any other adopted standard.

By observation, one can see that even the standard adopted for comparison is inadequate for evaluation of strength ratio based on scarf joint dimensions. Factors not allowed for include the grain alignment due to random assembly of scarf joints in fabrication, and the stress-concentration caused by the presence of the end step.

Effect of End Step Removal on Tensile Strength: A summary of the results of Part VII is presented as a histogram in Fig. 16. The strength ratios determined by experiment, the C.S.A. calculated strength ratio, and the efficiency of the former as compared to the latter are shown.

It was suspected and confirmed that the end steps of a scarf joint have a great effect upon the tension parallel-to-grain strength of single laminations containing these joints. The histogram of Fig. 16 illustrates this effect well.

Tensile Tests of Notched Unjointed Laminations: A comparison between strength ratio of unmatched scarf joints versus d/h and the strength ratio of the notched unjointed specimens (two notches, only one considered) versus d/h, is illustrated in Fig. 17. The difference between the two curves is attributed to scarf slope, grain alignment, and notch sensitivity of the scarf joints.

Summary of Conclusions: As a result of the studies outlined in this investigation of certain variables in scarf-jointed laminations, the following conclusions may be drawn:

1. Change in cross-sectional area of Douglas-fir specimens has no significant effect on the tension parallel-to-grain strength of that species.
2. Adjustment of various moisture content values to a common moisture content does not decrease the coefficient of variation nor change strength values significantly (5).
3. Strength ratios of single scarf-jointed laminations, when tested in tension parallel to the grain, are lower than those estimated by the provisions of the present C.S.A. specification for glued-laminated timber construction.
4. A non-linear relationship exists between the strength ratio and the depth of the notch created by the end step of scarf joints.
5. No significant difference in strength was found between comparable joints bonded with waterproof adhesive and casein glue in four of five shipments of scarf joints tested in this investigation.
6. The strength ratio of single laminations may be increased considerably by removal of the end-step notch on the outside faces of the laminations.
7. Tensile tests of notched unjointed laminations have confirmed the trend of decrease in tensile strength with increase in notch depth of scarf-jointed laminations.
8. Slope of grain steeper than 1:15 is found in Laminating Grade B lumber and is found on the wide face of flat-sawn boards; slope of grain on the edge of these boards meets the C.S.A. specification for this grade (5).

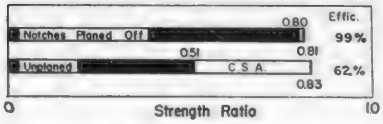
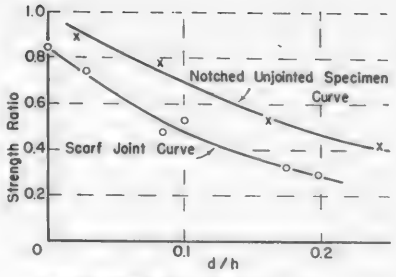


Fig. 16.—Histogram of effect of removing notches by planing of single hooked-scarf laminations.



Ultimate Tensile Strength Based on Gross Area

Fig. 17.—Variation of strength ratio with d/h.

Appendix

Extract from C.S.A. 0122–1953, Specification for Glued-Laminated Timber Construction

WORKING STRESSES

75. Working stresses in bending, tension, and compression parallel to grain for individual unscarfed laminations graded in accordance with "Selection and Grading of Laminating Stock" shall be the following percentages of the basic stresses given in Tables 1 and 2 after modification as necessary in Tables 3 and 4. Working stresses in longitudinal shear and compression perpendicular to grain are not reduced by grade.

Grade	Per Cent
A	90
B	75
C	60
D	50

76. Working stresses in tension for individual clear laminations in an assembly having plain scarf joints of the following slopes shall be the following percentages of the basic stresses given in Tables 1 and 2 as appropriately modified.

Table 6.—SUMMARY OF STATISTICAL VALUES OF SCARF JOINTS TESTED IN THIS INVESTIGATION

Specimen Group	No. in Group	Moisture Content % Avg.	Max.	Min.	Mean Tensile Strength psi	Std. Dev. psi	V %	Std. Err. of Est. psi
1HCC	8	12.1	13.2	11.5	11,659	2520	21.6	891
1HCU	18	11.9	12.9	10.5	6,132	926	15.1	218
1HRC	11	10.4	11.6	8.7	10,709	2307	21.5	696
1HRU	19	11.1	12.9	9.3	5,596	1379	24.6	316
2MCC	11	8.7	10.3	7.5	10,842	3153	29.1	951
2MCU	19	8.8	9.8	7.5	9,692	2114	21.8	485
2MRC	12	9.2	10.4	8.0	13,513	2751	20.4	794
2MRU	15	8.9	9.9	7.9	10,823	2378	22.0	614
3HCC	12	11.2	12.3	10.2	12,740	2130	16.7	615
3HCU	17	11.1	11.8	9.9	5,670	1110	19.5	269
3HRC	12	11.7	13.0	10.4	12,240	2660	21.7	768
3HRU	18	11.4	12.5	10.3	6,260	850	13.6	200
4HCC	19	12.1	13.5	10.7	11,110	3333	30.0	765
4HCU	19	11.7	12.5	10.8	3,820	810	21.2	186
4HRC	17	11.6	13.8	10.7	11,940	2424	20.3	588
4HRU	19	11.4	12.3	10.7	3,710	601	16.2	138
6HRC	14	12.3	14.2	10.2	12,820	2085	16.3	557
6HRU	19	12.6	13.6	11.2	3,740	430	11.4	98
7MCC	13	12.2	13.2	10.6	11,910	3780	31.8	1049
7MCU	17	11.9	12.8	11.1	8,840	1850	21.0	450
"0.87" in²	7	10.8	12.5	9.2	11,243	1432	12.7	541
"0.49" in²	7	11.1	11.3	10.7	12,767	5222	40.9	1974
SA	20	10.7	13.9	9.9	5,497	1117	20.3	250
SB	19	10.4	11.5	9.3	5,453	1323	24.3	304
SCC	7	11.0	12.5	10.3	13,281	3588	27.0	1356
SC	20	10.6	11.9	9.5	6,043	1065	17.6	238
SRC	7	10.8	11.7	9.2	10,729	3741	34.9	1414
SR	19	10.5	13.9	9.3	4,879	1067	21.9	245

Slope	Per Cent
1:12 or flatter	90
1:10	85
1:8	80
1:5	65

77. Working stresses in compression parallel to grain for individual clear laminations in an assembly having plain scraf joints of 1:5 or flatter slope shall have the same working stress as clear unscarfed laminations.

78. Working stresses in tension for individual clear laminations in an assembly having hooked or stepped scarfs with a slope of scarf face equal to those given in Clause 76 shall have the same percentages of basic stress as in Clause 75 except that the area of the step shall be considered the same as a knot or other growth characteristic in determining the net effective section, and the percentage reductions for scarf slope and net section shall be cumulative. Thus a lamination of 1-inch thickness having a 1:10 slope of scarf face and a 1/10-inch step has a net section of 90 per cent of the gross section and a reduction for scarf slope of 85 per cent of the basic stress; the strength of the scarf joint is then 76.5 per cent of the basic stress for a clear unscarfed lamination.

79. Butt joints shall be considered not to transmit stress in tension or compression.

80. Percentage reductions for grade and scarfing applied to basic stresses in determining working stresses of scarfed laminations of A, B, C, D, or other grade shall not be cumulative.

Acknowledgments

Grateful and sincere acknowledgment is made to R. F. DeGrace, Executive Vice-President of the Canadian Institute of Timber Construction, without whose help and personal guidance this entire project might not have been possible. Thanks are due to Professor C. F. Morrison, Head of the Department of Civil Engineering, University of Toronto, who introduced the writer to the project and acted in an advisory capacity. Acknowledgment is made to the Fabricating Division of the CITC for the manufacture of the many hundreds of specimens used in this research. The writer wishes to thank the Forest Products Laboratory at Ottawa for permission to use the text and data written and compiled at that Laboratory.

Thanks and appreciation are due to the Advisory Committee on Research of the University of Toronto and a special thank you is extended to the Canadian Lumbermen's Association for their Timber Research Fellowships.

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2. Anon. 1953. End joints of various types of Douglas-fir and white oak compared for strength. U.S.D.A. Forest Products Laboratory, Report No. 1622.
3. Henderson, C. C. 1955. Strength testing of scarf-jointed timber laminations. University of Toronto Thesis.
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6. Youngquist, W. G. 1951. Development of a new specimen for tension tests of wood parallel to the grain. U.S.D.A. Forest Products Laboratory.

Discussion

D. B. Richards: (Alabama Polytechnic Institute): How was a control sample set up?

Mr. Fox: Control pieces were made from the same boards as the scarf-jointed specimens. To begin with, a 1 by 8 inch board was ripped into three equal widths. The center strip was used for a control. The outside pieces were cross-cut, scarfed, and used for scarf-jointed specimens. One half of these were matched randomly to duplicate scarf joints used in actual fabrication of glulam. The other half were rematched number by number.

Dr. Richards: What results did you get with the perfectly matched scarf joints?

Mr. Fox: The matched specimens were found to be from 1% to 12% (in most cases 3%) greater in strength ratio than the unmatched specimens. Statistical "t" tests at a 5% level of confidence indicated that in most cases there was no significant difference between matched and unmatched joint strengths.

Dr. Richards: What controls did you compare each joint to?

Mr. Fox: For purposes of my paper, I did not compare individual scarf joint values with the respective control values, but rather compared the average strength of a scarf joint group with the average strength of the respective control group. However, at the Ottawa Forest Products Laboratory, individual values were compared and the average of these ratios were computed to reveal strength ratios which were very similar to those computed by the first method.

Dr. Richards: What actual tensile strength was obtained by the controls?

Mr. Fox: Examination of the average tensile strengths of the control specimens of the scarf joints would show that these ranged from 10,700 psi to 13,500 psi. These control specimens included ones with cross-grain and were not to represent straight-grained wood but rather Laminating Grade B lumber which has a requirement that the maximum slope of grain be 1:15.

John M. Yavorsky (State University of N. Y. College of Forestry): On what basis was the C.S.A. specification drawn?

Mr. Fox: The C.S.A. specification for scarf joints in tension is based on tests of the U.S. Forest Products Laboratory.

Dr. Yavorsky: Have the C.S.A. specifications been checked before?

Mr. Fox: So far as I know, these were the first tests of hooked-scarf joints whose results have been announced publicly. It is the first time that this particular specification has been checked and, as far as I know, it is the first time any specification on the tensile strength of scarf joints has been checked.

Dr. Richards: Were results of the tests uniform and consistent?

Mr. Fox: In my estimation, the test results were consistent.

Alan Marra (University of Michigan): Could any results be traced to quality of gluing rather than type of scarf?

Mr. Fox: The joints were made at different factories. They were assumed to be well made joints and this is substantiated by the estimated percentage wood failure data gathered during the tests. Less than 2 per cent of the scarf-

Table 7.—SUMMARY OF STATISTICAL VALUES OF NOTCHED UNJOINTED SPECIMENS TESTED IN THIS INVESTIGATION

Specimen Group	No. in Group	Moisture Content % Avg.	Max.	Min.	Mean Tensile Strength psi	Std. Dev. psi	V %	Std. Err. of Est. psi
Notched Unjointed—Controls								
E	8	9.4	10.2	8.7	14,056	4072	29.0	1440
F	9	10.1	11.3	9.7	15,570	4742	30.5	1581
G	10	10.1	10.9	9.0	15,844	3454	21.8	1092
H	9	10.0	10.6	9.0	15,161	2217	14.6	739
Notched Unjointed—One Notch on One Side, Centered								
E	9	10.9	11.8	10.0	13,002	3950	30.4	1317
F	10	11.2	11.9	10.5	13,323	4106	30.8	1298
G	8	11.0	11.8	10.0	8,188	4057	49.5	1434
H	9	10.8	11.9	10.0	7,867	3559	45.2	1186
Notched Unjointed—One Notch on Each Side, 9" Apart								
E	9	10.4	11.6	9.2	12,471	2882	23.1	961
F	9	10.9	12.1	10.2	12,008	4143	34.5	1381
G	10	11.3	12.1	10.0	8,414	4115	48.9	1301
H	10	11.2	12.6	10.5	6,478	2307	35.6	730

V = Coefficient of Variation

jointed specimens showed less than 50 per cent wood failure.

B. B. Lane (The Lane Co.): How did hook scarf joints vary between manufacturers?

Mr. Fox: The depth of hook varied from 0.065 inches to 0.150 inches while the thickness of the joint tip varied from 0.050 inches to 0.130 inches. All joints supplied had a scarf slope of about 1:12.

Mr. Lane: Why use a hook scarf?

Mr. Fox: The hook, or center step, of this type of scarf joint acts as an alignment aid during the assembly procedure of glulam products.

M. J. Rhude (Unit Structures): Was quality of machining on the scarfs effective on quality of the joint?

Mr. Fox: The effect of the machining on the quality of the joints is not known.

Andrew Rapavi (Bureau of Ships): With teak decking laminated to Douglas-fir, on 80 consecutive scarf joints 1:12 ratio tests showed 88 per cent of original strength.

Mr. Fox: That may be true but what you speak of are bending tests and I do not think bending tests are as severe as tension parallel-to-grain tests.

John L. Hill (Alabama Polytechnic Institute): You said you had some cross-grain failures. Were these values included in the determination of strength reduction factors?

Mr. Fox: Cross-grain failures were included in the determination of the strength reduction values since these tests were tests of Laminating Grade B lumber and were not meant to be tests of selected straight grained-material.

Safe Bending Radii for Curved Laminates[1, 2]

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and

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An investigation is being conducted to determine minimum safe radii of curvature for woods commonly used in the U. S. Navy's wood ship building program. Empirical formulae for practical, safe bending radii have been developed for African mahogany, Douglas-fir, and white oak. The relative bending properties of these species and of Philippine mahogany, Honduras mahogany, and preservative-treated red oak have been determined.

Introduction

IN LESS THAN THREE DECADES, the use of glued laminated timbers for structural purposes has sprung like a fountain from a novel curiosity, to a bubbling enterprise. In every corner of the United States, laminated structures are fulfilling the requirements for many architectural and engineering needs, not only for strength purposes, but also for aesthetic value. The development of fully waterproof and durable adhesives in recent years has even made wood laminates, when properly fabricated, totally reliable for outdoor exposure and for marine application (Fig. 1). Truly, it is one of the great advancements in the use of wood, or any other structural material, in this century.

From extensive research conducted by a number of organizations, and improved technical developments on the production level, a great deal has been learned about wood laminating and use of wood laminates. There are also many unanswered questions.

Aside from the need for the glue bonds to be fully waterproof and able to withstand severe exposure to salt water and extremes in wetting and drying, the production of wood laminates for marine service poses some peculiar problems not generally encountered in producing laminates for most other structural applications.

One of the pertinent problems involved in the production of wood laminates, for use in U. S. Navy wooden ships and boats, was the large variety in sizes and shapes of the various members going into a given vessel. Some of these members required the individual layers of wood (lamination), making up a member, to be bent to rather sharp radii of curvature. Since it was known that bending of wood to too sharp a curvature would cause rupture, the Bureau of Ships was faced with the question as to what extent a piece of lumber could be bent without damage.

From a study of the available literature, it was found that relatively little information has been published about the ability of wood to be bent in the dry, unheated state. Most sources of information agreed that the thickness was the principal factor governing the radii of curvature to which wood could be bent without damage. Various formulas were developed on the basis of theoretical consideration which showed variability in the radius of curvature to which a given wood could be bent as some constant times the thickness. The judicious use of these equations for production purposes appeared to require rather impractical lumber thicknesses.

Other sources of information showed radii of curvature considerations based on actual tests in which lumber of different thicknesses had been bent to rupture, and the resulting values adjusted to give an approximated safe bending radius of curvature value for each thickness.

The radius of curvature-lamination thickness relationship in U. S. Military Specifications governing the production of wood laminates for Navy use were evolved in this manner. Although more practical than the theoretically derived formulas, in production there were indications that for

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[1] Presented at Session VI, Glues and Gluing, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

[2] The views expressed by the authors are not to be construed as representing those of the Department of the Navy.

The Authors: W. J. Finnorn holds B. S. degree in forestry from Louisiana State University, has been a member of the Teco laboratory staff since 1951.

Andrew Rapavi received B. S. in wood technology from State University of New York College of Forestry, Syracuse. He specializes in marine laminating and adhesives in his present position.

—Official U. S. Navy Photo

Fig. 1.—Erecting the laminated wood stem of a minesweeper.

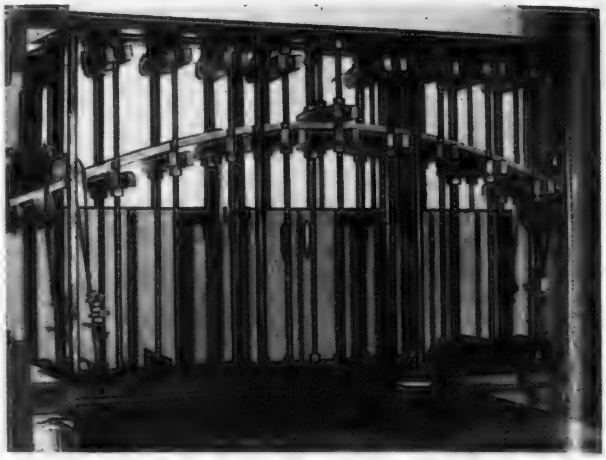

Fig. 2.—Rig used to test the bending properties of several common shipbuilding woods. Blocks were set at desired radii by aligning them with radii scribed on the template directly behind the apparatus.

some lamination thicknesses, the permitted radii of curvature were too sharp. There were also indications that some thicknesses of lumber could be safely bent to a sharper radii of curvature.

Therefore, the true nature of the radius of curvature to which wood of a given thickness could be bent without damage was open to investigation. There was a definite need for a reliable, reproducible method for determining this relationship and for determining what extent defects such as slope of grain, knots, etc., affected the "bendability" of the wood.

White oak and Douglas-fir, two of the most widely used ship and boat building woods, were selected for the more detailed preliminary study. Less extensive research included African, Philippine, and Honduras mahogany and Tanalith- and pentachlorophenol-pressure preservative-treated red oak.

The work covered in this paper was limited primarily to clear straight-grained lumber, except for the mahogany species which inherently possess interlocked grain. However, future work is expected to be conducted to determine the effects of defects, such as knots and slope of grain, on the bendability of wood.

Experimental Procedure

General Test Methods: To determine the minimum safe radii of curvature of various species, boards 6 inches wide and 6 feet long, of various thicknesses, were bent to successively smaller radii of curvature until failure occurred. The apparatus used for this operation was constructed to simulate, as nearly as possible, laminating equipment used in industry (Fig. 2).

A main framework of 3-inch channel iron and ¾-inch pipe held ¾-inch threaded rods parallel to one another and spaced six inches center-to-center. The framework was constructed to take specimens up to 7 inches wide. The threaded rods were equipped with nuts which could support wooden blocks. By means of the nuts, these blocks could be arranged at various curvatures down to a semicircle 24 inches in radius.

In order to simulate the restraining clamps used in laminating practice, each set of threaded rods was equipped with a block opposing that which formed the radius. These blocks were to be used in the event that a specimen did not maintain full contact with the radius throughout the test. To insure smooth curvature over the blocks forming the radius, a ⅛-inch steel caul was used.

Each board was clamped at its center to the apex of the curved form. The specimen was then bent to curvature by means of a manually operated, 3-ton chain hoist and a pair of cables which were attached to the ends of the boards in such a manner as to avoid end-restraint as bending progressed.

The initial radius of curvature to which boards of a given thickness were bent was determined by the equation:

$$R_i = \frac{0.75\ Ed}{r} + 12^*$$

* This equation is based on the proportion:

$$\frac{r}{E} = \frac{0.5d}{R}$$

where:

r = fiber stress at proportional limit, psi
E = modulus of elasticity, psi
d = board thickness
R = radius of curvature

This proportion used in mechanics is only approximately correct; however, it was used as a guide. It was re-written and the value of R was increased by 50 per cent plus 12 inches:

$$R = \frac{(0.5Ed \times 1.5)}{r} + 12 = \frac{0.75Ed}{r} + 12$$

This formula assured a starting radius well above the radius to proportional limit.

where:

R_i = Initial test radius of curvature, inches
E = Modulus of elasticity, psi
d = Board thickness, inches
r = Fiber stress at proportional limit, psi

After boards of one thickness were bent to their initial radius, bending

Fig. 3.—The table on which testing was continued on boards which bent below 24 inches.

was continued at successively smaller radii until all specimens had failed. The radius was reduced by increments of 12 inches for radii over 120 inches, 6 inches far radii between 60 and 120 inches, 3 inches for radii between 30 and 60 inches, and 2 inches for radii below 30 inches. This method was adopted in order to prevent any reduction in radius greater than 10 per cent of the total radius involved.

Several boards were bent to a 24-inch radius of curvature without failing. This was the limit of the testing rig; therefore, a steam-bending table was modified to handle the bending operation for radii below 24 inches (Fig. 3). Boards were bent on this table in a horizontal plane around a male form. Forms were made and mounted on the table for each even radius from 24 to 10 inches and for each inch of radius from 10 to 7. Boards were clamped at their longitudinal centers to the apex of the form and bent from both ends.

The amount of set induced by bending was measured at each radius. Before being bent, each board was supported over a 4-foot span and a dial gauge, reading in thousandths of an inch, was used to measure any bow in the specimen. After the initial measurement, the specimen was inserted into the bending jig, clamped into place at its center, and brought into contact with the curve. The board was held at full curvature for several seconds, then released and removed from the apparatus. Five minutes after being bent, the specimen was again measured for bow.

All boards were kept standing on edge before and after each measurement and between bends in order to allow free recovery.

The amount of measured set, determined by substracting initial from final readings, was computed for every board at each radius to which it was bent. It was found that as the radius was decreased, the set increased at a constant rate until a critical radius was reached at which a large increment of set appeared. This set was followed, at smaller radii, by a corresponding series of larger increments continuing until failure occurred. The critical radius was assumed to be the radius which deformed the board beyond its proportional limit.[3] When a specimen failed, the radius of curvature was noted and a wafer was cut from the board for measuring moisture content and specific gravity.

[3] The proportional limit radius, referred to in this paper, is the sharpest radius to which a board can be bent without exhibiting significant permanent deformation. This should not be confused with fiber stress at proportional limit, which is the maximum stress, rather than the sharpest radius, to which wood can be subjected without being permanently deformed.

Table 1.—SUMMARY OF BENDING RESULTS ON ¾-INCH BOARDS OF VARIOUS SPECIES

Species	No. of boards	Specific gravity*	Moisture content Per cent	Average radius at proportional limit Inches	Radius causing failure	
					Maximum Inches	Average Inches
African mahogany	15	0.46	11	91	66	54
Honduras mahogany	6	.46	11	98	60	53
Philippine mahogany	6	.60	8	95	78	57
White oak	6	.66	10	102	48	42
Douglas fir	6	.42	8	108	84	66
Red oak (penta-treated)	6	.68	10	103	32	29
Red oak (Tanalith-treated)	6	.68	14†	102	28	23

*Specific gravity calculations based on oven-dry weight and volume.
†The six Tanalith-treated boards were conditioned to what was believed to be 10 per cent moisture content. However, after testing the specimens, moisture content determined by the oven-dry method was found to be 14 per cent. The slight difference between Tanalith- and penta-treated red oak in proportional limits and rupture radii may possibly have been due to the difference in their moisture contents. However, a plotting of rupture radius over moisture content indicated that, over the moisture content range within each species (3 to 4 per cent), moisture content did not significantly affect breaking radius.

Table 2.—SUMMARY OF BENDING RESULTS FOR WHITE OAK, DOUGLAS-FIR, AND AFRICAN MAHOGANY BOARDS 6 INCHES WIDE AND 6 FEET LONG, MEASURED OVER A 4-FOOT SPAN

Species	Thickness Inches	No. of specimens	Average moisture content Per cent	Average specific gravity*	Average proportional limit radius Inches	Radius causing failure	
						Maximum Inches	Average Inches
White oak	1	12	12	0.69	140	78	45
	⅞	13	12	.72	120	66	46
	¾	6	10	.66	102	48	42
	⅝	13	10	.73	89	48	32
	½	13	11	.70	72	34	21
	⅜	13	11	.74	59	20	16
	¼	13	11	.72	39	16	10
Douglas fir	1	13	11	.46	140	114	89
	¾	6	8	.42	108	84	66
	½	13	12	.53	76	60	44
	¼	13	9	.55	40	37	25
African mahogany	1	12	12	.50	†	90	72
	¾	15	11	.46	91	66	54
	½	14	12	.49	69	42	35
	¼	18	11	.45	36	36	20

*Based on oven-dry weight and volume.
†Tests were begun on these specimens at too small a radius; therefore, the resulting proportional limit values were unreliable and consequently not included in the table.

Material Tested: Six species were included in the study: Douglas-fir *(pseudotsuga taxifolia)*, white oak *(Quercus* spp.), African mahogany *(Khaya* spp.), Philippine mahogany *(Shorea* spp.), Honduras mahogany *(Swietenia macrophylla)*, and red oak *(Quercus* spp.) treated with Tanalith and pentachlorophenol.

Seven thicknesses of white oak and four of Douglas-fir and African mahogany were tested. Only one thickness of each of the three remaining species was examined, since these woods are less commonly used in Navy laminating and since the purpose for testing them was only to obtain an estimate of their bending properties as compared with the three former species.

This series of tests was preliminary and was confined to clear, straight, grained material, except for the mahogany species which characteristically contain interlocked grain.

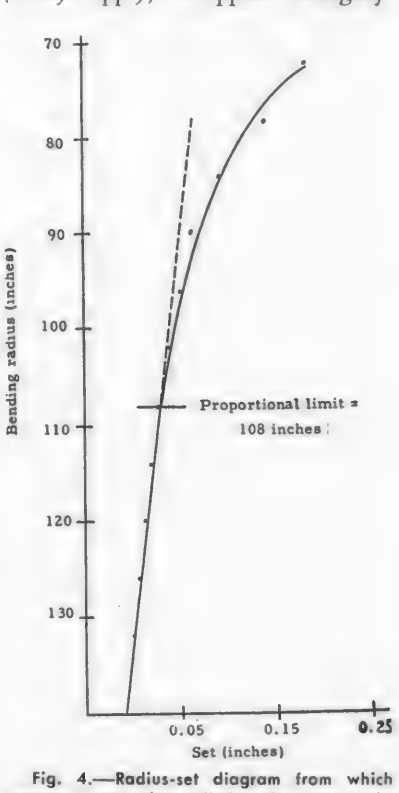

Fig. 4.—Radius-set diagram from which average proportional limit values were obtained for ¾-inch Douglas fir.

Results and Discussion

Test Data: Data pertaining to bending tests conducted on ¾-inch thick lumber of the six species included in the study are summarized in Table 1. The average proportional limit radii given in this table were obtained by plotting radius of curvature over the average set induced by bending boards to a given radius, as shown in Fig. 4.

As seen in Table 1, the oaks, particularly Tanalith-and penta-treated red oak, were bent, without breaking, to much smaller radii of curvature than were the other species tested.

Douglas-fir was least capable of being bent to severe curvature. African and Honduras mahogany were similar in bending properties, while Philippine mahogany, which has a much higher specific gravity, failed at larger radii of curvature.

Results of bending tests conducted on several thicknesses of white oak, Douglas-fir, and African mahogany are presented in Table 2.

A "radius-thickness" graph was plotted for each species included in Table 2. The proportional limit radii and the largest radii at which failure occurred were plotted over thickness (Fig. 5, 6, and 7). Within the range studied, proportional limit proved to be approximately a linear function of board thickness. The relationship between thickness and maximum radius causing rupture was non-linear and less consistent.

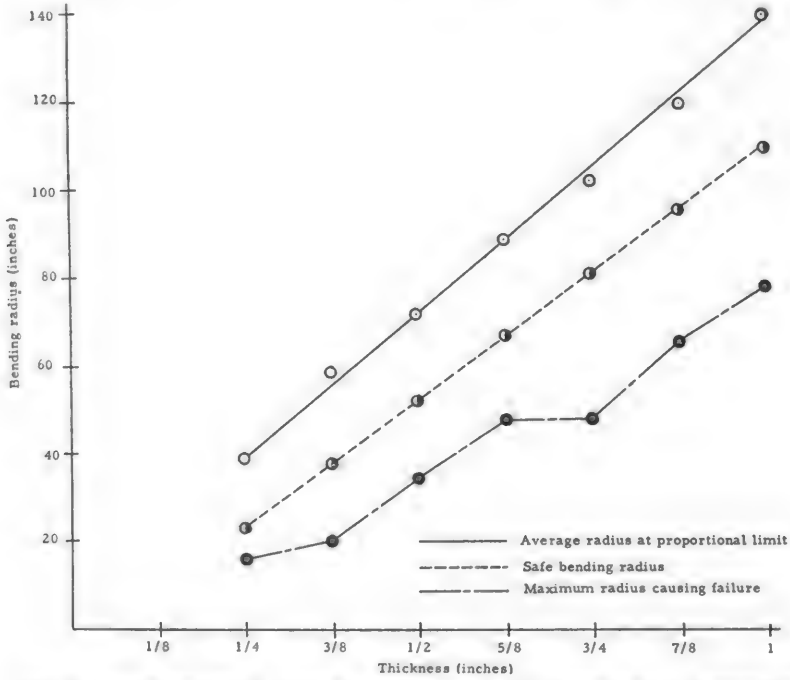

Fig. 5.—The relationship in white oak of thickness to: (1) average radius at proportional limit (upper line); (2) safe bending radius (central line); and (3) maximum radius causing failure (lower or broken line).

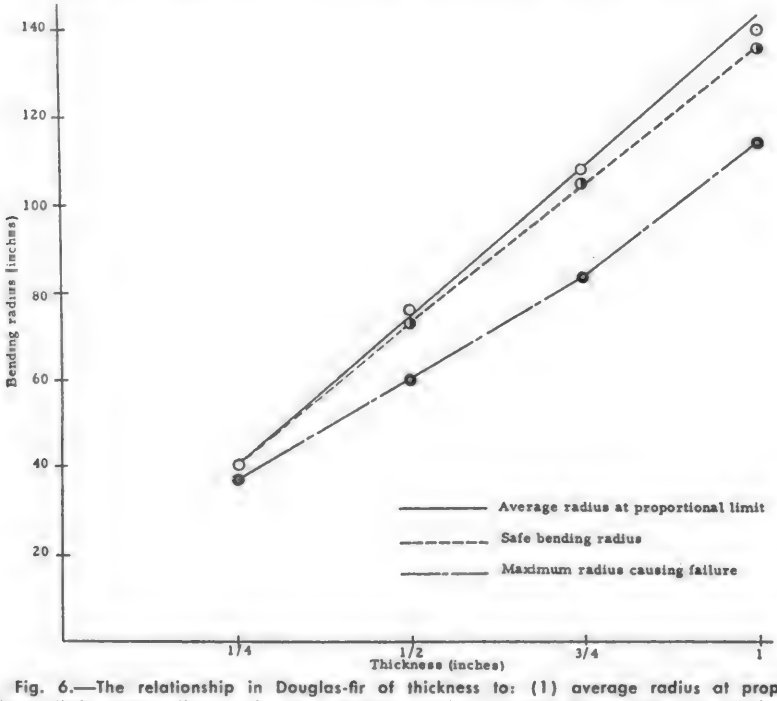

Fig. 6.—The relationship in Douglas-fir of thickness to: (1) average radius at proportional limit (upper line); (2) safe bending radius (central line); and (3) maximum radius causing failure (lower line).

Safe Bending Radii Formulae: From a structural design standpoint, an absolutely safe bending radii formula should assure that no board will ever be stressed beyond proportional limit while being bent to laminating curvature. However, results of this study indicate that a formula this conservative, applied to the curvatures used in modern wood ship design, would require such thin laminations that the gluing of curved wood ship members would be economically prohibitive.

It therefore became necessary to develop a formula which would permit the use of thicker lumber and still furnish a reasonable degree of safety. The formula which was finally devised allowed lumber to be bent to curvatures that stressed some boards slightly beyond proportional limit, but which was conservative enough to assure that no boards would fail while being bent to the specified radii.

An important factor, considered in the development of the safe bending formula, was the relative ability of various wood species to be bent, without failing, to curvatures sharper than the proportional limit radii. This property varies with species. For example, it can be noted in Table 1 that the average proportional limit radii for 3/4-inch white oak and Douglas-fir were similar, 102 and 108 inches, respectively. However, white oak was bent to the relatively sharp radius of 48 inches before a specimen broke, while failure occurred in Douglas-fir lumber at 84 inches.

In the formula, allowance was made for this property by combining the average radius to proportional limit and the maximum radius causing rupture. The proportional limit radius was reduced by a quantity equal to the difference between it and the maximum radius causing rupture, multiplied by this difference divided by proportional limit radius. This can be more simply expressed mathematically as follows:

$$R_s = R - (R-R_x)\,\frac{(R-R_x)}{R}$$

$$R_s = 2R_x - \frac{R_x^2}{R}$$

where:

R_s = safe bending radius, inches
R_x = maximum radius causing failure, inches
R = average radius stressing boards to proportional limit, inches

Values were obtained with this formula for various thicknesses of white oak and Douglas fir and were plotted on graph paper. Balanced straight

lines through these points are shown in Figs. 5 and 6. They have the following equations:

White oak:

$$R_s = 116t - 6$$

Douglas fir:

$$R_s = 126t + 10$$

where:

R_s = safe bending radius, inches
t = board thickness ¼ to 1 inch, inclusive

The foregoing method for determining safe bending radii cannot be applied to African mahogany because, for ¼-inch material of this species, the largest radius at which a board failed coincided with the average proportional limit radius (Table 2). This early failure probably occurred because, in thin plain sawed boards, interlocked grain becomes simple cross grain which fails more readily than interlocked grain.

A safe radius for African mahogany was therefore obtained by increasing the proportional limit curvature by 5 inches at each thickness. A straight line through these points (Fig. 7) represents the safe bending radii formula and has the following equation:

$$R_s = 124t + 10$$

Conclusions

1. On the basis of this study, the following woods are listed numerically according to their ability to be bent to severe curvature:

1. Red oak (treated with Tanalith or pentachlorophenol)
2. White oak
3. African and Honduras mahogany
4. Philippine mahogany
5. Douglas-fir

2. Within the range of thickness practical for laminating curved ship members, ¼ to 1 inch, the relationship between board thickness and proportional limit radius is approximately linear for the species studied.

3. The following "safe curvature" formulas were developed from empirical data obtained during this study:

white oak $R_s = 116t - 6$
Douglas-fir $R_s = 126t + 10$
African mahogany $R_s = 124t + 10$

where:

R_s = safe bending radius, inches
t = board thickness, ¼ to 1 inch, inclusive

4. The preceding formulas are based on defect-free material and should therefore be applied only to very high quality laminations. Additional work is necessary and anticipated which will determine the effect of lumber defects on the allowable safe curvatures.

5. The formulas developed as a result of this study are safe in that they assure that laminations will not fail on being bent to curvature, but they do allow some boards to be bent beyond proportional limit. Additional work must be conducted to determine the exact effect of individual layers stressed beyond proportional limit, on the strength of laminated curved members.

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Discussion

Henry A. Huber (Dow Chemical Co.): At what moisture content was the material tested?

Mr. Finnorn: Most boards fell within a moisture content range of 10–12 per cent; however, the six Tanalith-treated boards averaged 14 per cent and six Philippine mahogany and six Douglas-fir boards were tested at an average moisture content of 8 per cent. An examination of data showed that, within the range observed, moisture content had no significant effect on bending radius.

L. E. Clark, Jr. (Perkins Glue Co.): Could five minutes time after a board had been bent be considered to be permanent set?

Mr. Finnorn: No. If boards were left longer and had not exceeded their proportional limit, they would probably have recovered completely in time.

Mr. Clark: If a board had been bent to the same curvature several times, would the set have been the same?

Mr. Finnorn: This was not done; therefore, I cannot give a positive answer. However, I believe that if a board is not bent to proportional limit, it should have equal recovery rates on being bent several times to a given radius.

Mr. Clark: If it took 50 lbs. to bend a board, would there be 50 lbs. of springback?

Mr. Finnorn: No measurement was

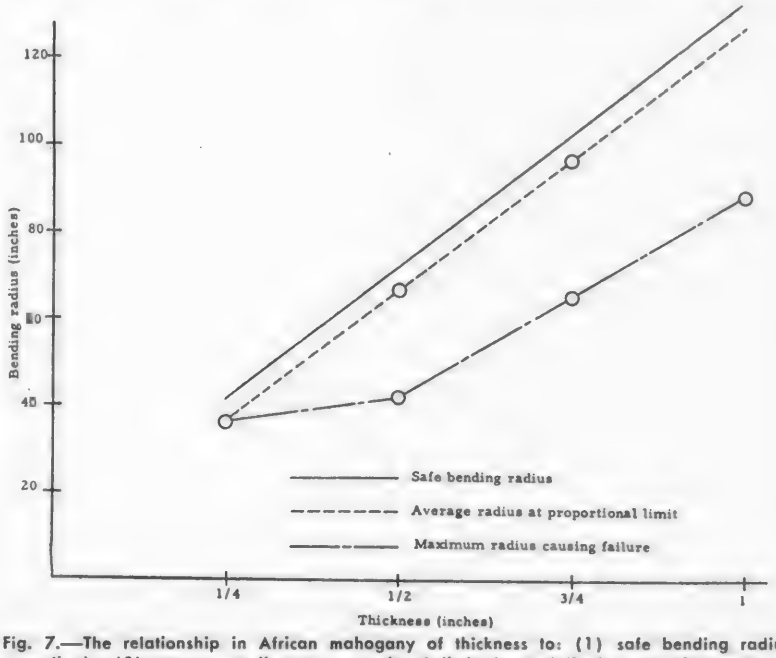

Fig. 7.—The relationship in African mahogany of thickness to: (1) safe bending radius (upper line); (2) average radius at proportional limit (central line); and (3) maximum radius causing failure (lower line).

made of stresses applied. No answer is available.

Alan A. Marra (University of Michigan): If moisture content did not appear to affect the bending radius within the range observed, can we say that moisture content does not affect the safe bending radius? In other words, would higher or lower moisture contents give different safe bending radii?

Mr. Rapavi: Within the 9 – 12 per cent moisture content range, there was no consistent difference in bendability. However, in actual practice, it has been found that more breakage occurs when boards of equal thickness are bent at 6 per cent than when bent at 14 per cent moisture content.

Dr. Marra: I was wondering whether the rank of Douglas-fir with respect to the other species might have been partly due to its lower moisture content.

Mr. Finnorn: We cannot conclude this merely on the basis of the lower moisture content of the ¾-inch Douglas-fir. At thicknesses other than ¾-inch, the average moisture contents of white oak, Douglas-fir, and African mahogany were equal or within 1 per cent of one another, yet the larger breaking radius for Douglas-fir is consistent at all thicknesses.

Dr. Marra: Do you have any information as to how moisture content affects the safe bending radius for each species? It would seem to me that if an effect exists, a further refinement in your formula might be made by the addition of a factor which would account for it.

Mr. Rapavi: We have not studied a wide moisture content range to determine its effect on safe bending radius for each species. However, for the range which occurred in this study, moisture content apparently had little effect on bending radius.

J. R. Stillinger (Cascades Plywood Corp.): Does specific gravity affect safe bending radius?

Mr. Finnorn: As in the case of moisture content, the range of specific gravity within species had no significant effect on bending radius.

Dr. Stillinger: Did you determine the ring count in the Douglas-fir test specimen?

Mr. Finnorn: The ring count of Douglas-fir was not tabulated, but the growth rate was moderate and the average specific gravity was similar to published values.

Mr. Stillinger: Did you determine the specific gravity of each test piece and if so, did the average values indicate the test material was representative for the species?

Mr. Finnorn: We determined the specific gravity of each board tested and the average values indicate that the test material was representative for each species.

Anon. (Perkins Glue Co.): What was the measurable difference in Ames dial reading with respect to set?

Mr. Finnorn: This varied with species. For example, the set increase at each radius before proportional limit was reached was approximately 0.01 inch for ½-inch white oak and about half as much for ½-inch fir.

A. Luning Prak (N. C. State College): What was the effect on bendability of different drying conditions?

Mr. Finnorn: This was not checked but variations in normal drying would not be expected to affect it.

Dr. Stillinger: Was bendability different for close-grain, old-growth Douglas-fir compared with the wider ring material?

Mr. Rapavi: All work was done with average grain old growth. No comparison is possible.

Genetic, Growth, and Environmental Factors Affecting Specific Gravity of Loblolly Pine[1]

BRUCE J. ZOBEL

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Studies on wood specific gravity are part of an intensive program of forest genetics research underway by the Texas Forest Service. Final results are not available, but it was found that the commonly considered specific gravity determiners such as growth rate, age, site, etc., taken singly or in combination, contributed only a small proportion to observed specific gravity variations. A relationship between specific gravity of juvenile and mature wood is also reported, with its value and application briefly discussed.

IN WOOD SPECIFIC GRAVITY studies of loblolly pine *(Pinus taeda* L.) currently underway by the Texas Forest Service, it has been found that:

1. A number of "circumstantial evidence" results point to the control of wood specific gravity by other than growth and environmental factors.

2. Trees of very high and very low specific gravity were found on each plot studied, even though each plot was on a uniform site and the trees were essentially even aged.

3. No one growth or environmental characteristic could be found to have a strong influence on specific gravity.

4. When the various growth and environmental factors were considered together, they accounted for only a small amount of the specific gravity variation.

5. A very strong correlation was found between the specific gravity of the wood of a mature tree and its juvenile wood. From this and from a relationship of branch-to-bole wood of small trees, a possible shortcut method exists in which it may be possible to predict the specific gravity of a mature tree from a very young tree without destroying the young tree.

For many years it has been recognized that the characteristics of lumber and pulp products are largely dependent on the nature of the tracheids and fibers that combine to form the wood in the living tree. The field of wood technology deals to a large extent with various properties of wood and their significance in product utilization.

One of the properties of wood that has been studied most intensively is that of specific gravity, or wood density. This property of wood is important in both the pulp and lumber industries. Manufacturers of some Kraft papers want wood of high specific gravity, while those that produce products such as high-grade writing paper want wood with uniformly

[1] Presented at Session X, Logging and Milling, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

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Fig. 1.—This is one of the plots on which the effects of environment and growth on specific gravity were made.

thin-walled fibers and tracheids. The importance that specific gravity can play in pulp yields has been mentioned by Mitchell (3).[2] The grade of lumber is partially determined by the specific gravity of the board, as usually estimated from its summerwood content.

All industries that deal with wood products or wood cellulose are to some degree affected by the specific gravity of the trees they use as their raw product. Because of its importance and because of its ease of measurement, many studies have been made on specific gravity of wood. This paper will consider those specific gravity studies that deal with the conditions that determine specific gravity in the living tree.

Much literature is available on this subject. It has been adequately reviewed in recent articles by Loe and Mackney (2), Mitchell (3), Paul and Smith (4), Pillow (5), Rees and Brown (6, Spurr and Hsuing (7), Zahner (8) and Zobel and Rhodes (9). No comprehensive review will be attempted here, with only a few of the more pertinent articles being cited.

Literature on specific gravity is in a state of confusion with numerous contradictory statements readily apparent. Most specific gravity research has been characterized by the tendency to ascribe one factor as the only causal or controlling factor of wood specific gravity. There are champions for rate of growth, for age, for site, for soil moisture, for crown characters, and many others. Recently, champions have arisen for the genetic control idea, who feel that specific gravity will not be greatly changed despite varied environmental and growth conditions.

An intensive study of specific gravity relationships indicates that not one of the so-called champions is correct if he deals with a single factor only. It is probable that each characteristic which affects the tree's life and growth has some effect on the specific gravity of the wood that the tree produces. It is not a simple case of one factor being all-controlling. Rather, it is the resultant of the reaction and interaction of several factors, each of which contributes to the specific gravity.

In forest genetics research, the parent-offspring relationship is of major interest. In undertaking research on the hereditary nature of the specific gravity character, however, it was immediately obvious that the varied environmental and growth characteristics must be considered along with the factor of inheritance. Since many of our preliminary observations did not agree with some published findings, it was necessary to branch off into certain "non-genetic" studies in order to have a firm foundation on which to base the genetic research.

Research Underway

The primary research on wood specific gravity now underway by the Texas Forest Service is of a genetic nature. Simply stated, it is an attempt to find out how much the specific gravity of any particular tree has been determined by its inherent specific gravity, i.e., by the specific gravity of its parents. Such studies are long term and must be made under as uniform environmental conditions as possible. Few results are as yet available on these strict genetic investigations, although from them have arisen certain "circumstantial evidence" results that will be reported in this paper. Positive results must await the maturation of the trees (and wood) under study.

The second type of research underway deals with the possible effects that various growth and environmental factors will have on specific gravity. Certain phases of this work have been completed and a summary of the results are reported here. From these results it could be possible to determine which are the most important factors in producing trees of a desired specific gravity.

Research Results

An intensive, statistically designed experiment was initiated in East Texas to assess the contribution of certain growth and environmental factors to specific gravity. Among those taken

[2] Numbers in parentheses refer to literature cited

Fig. 2.—Only best dominant and codominant trees were used in the specific gravity study. No deformed, spiral, or damaged trees were sampled.

under consideration were: growth rate, tree age, site index, soil characters, per cent summerwood, per cent clear bole, moistness of site, and stand density (basal area).

Fifteen plots of 50 trees each were selected on a number of various sites in East Texas (Fig. 1). Stands were essentially even aged and sites were as uniform as it was possible to find. Average ages of plots varied from about 25 to 60 years. Only the best dominant and codominant trees were sampled (Fig. 2).

Two types of analyses were made. First, correlations were determined within each plot for the effect that the various factors measurable on individual trees would have on each tree's specific gravity; for example, age or growth rate. Additional correlations were made between averages of all trees on the plot and average specific gravity of the plot for factors such as growth rate and age as well as for those factors only measurable on a plot unit, such as site, soil moistness, and stand density.

When each factor was considered singly within a plot, the following generalized results were obtained from these studies:

1. There was a very weak relationship between the age of a tree and its specific gravity. On only one of the 15 plots was a slightly significant correlation found between age and specific gravity. Therefore, on the relatively uniform site of each plot the older trees did not have significantly higher specific gravities than the younger trees.

2. There was likewise only a very weak relationship between growth rate and specific gravity, with a barely significant relationship being found on one of the 15 plots. This means that the faster growing trees did not always have the lower specific gravities, as has often been reported in the literature.

3. Practically no relationship whatsoever could be found between percentage of clear bole and specific gravity of a tree. It has been reported that the specific gravity of a tree can be predicted merely by noting how well it has pruned, or by how much of the bole has retained a live crown. In this study no significant correlations were obtained.

4. As reported by practically all workers, a relatively strong relationship was found between specific gravity and per cent summerwood. This correlation was not quite as strong, or direct, as reported by some workers. Of all variables studied, however, the only one that can be used to estimate specific gravity with any degree of accuracy is per cent summerwood. High per cent summerwood is usually associated with high specific gravity.

When the several factors were considered simultaneously, on any one plot, it was found that:

1. By methods of multiple correlation, the total effect of growth rate, age, and per cent clear bole accounted for only a small proportion of the specific gravity variations. Actually, the multiple correlations indicate the sum total of all growth and environmental factors contribute only a small per cent of the indicated specific gravity. In other words, a combination of the factors studied could not be used to reliably predict what the specific gravity of any tree would be.

2. When each variable was considered independently as averages on a plot level, relationships between plots were as follows:

a. There was a significant, but weak, relationship between age and specific gravity. Older trees tended to have higher specific gravities.

b. There was a significant, but weak relationship between growth rate and specific gravity. Slower growth trees tended to have higher specific gravities.

c. There was a slight relationship between per cent clear bole and specific gravity. The limbier trees tended to have slightly higher specific gravities.

d. There was a very weak relationship between site and specific gravity, the better sites (higher site index) tending to have the lower specific gravities.

e. There was no relationship between moistness of site and specific gravity.

f. Stand density had little or no relation to specific gravity.

The validity of the above mentioned between-plot relationships may be questioned. As emphasized by Zobel and Rhodes (9), an analysis of the 15 plots showed that each was significantly different from the others in all variables tested; therefore, they are assumed to represent different populations. Grouping of data from different populations must be done with caution, since there is danger of actually combining data from different genetic populations.

Relationship of Juvenile to Mature Specific Gravity

This study was initiated to see if the specific gravity of the wood produced by a young tree was indicative of the specific gravity of the wood the same tree would produce when it was mature. By taking samples from mature trees and working backward, through the radial section, it was possible to determine the relationship of juvenile wood (in this study, the first 8 years) to the mature wood.

Two groups of loblolly pine were used in this test. The first consisted of about 100 trees in an even-aged (42-year-old) stand on a relatively uniform site. Trees were of average specific gravity. Only the best formed dominants and codominants were used (Fig. 2). The other population also consisted of about 100 trees that were obtained from all available sites. It was comprised only of trees of very high or very low specific gravity which were selected irrespective of site. Both populations were confined to East Texas.

Both groups of trees, despite their differences, showed a very strong relationship between the specific gravity of juvenile wood and mature wood of the same tree. Correlation coefficients of approximately .85 were obtained, which are extremely high when the difficulties of analyzing very small wood samples adequately are considered.

These data indicate that a tree which produces wood of low specific gravity when young will continue to produce relatively low specific gravity throughout its lifetime. This is another piece of "circumstantial evidence" in favor of the genetic control viewpoint. Ultimate wood specific gravity, whether it be relatively high or low, appears to be manifested early in the tree's life. The actual specific gravity produced may vary from year to year depending on various conditions, but some trees tend to be relatively high, others relatively low, no matter what conditions are present.

In order to use the juvenile-mature wood relationship in studies on seedlings, a test was run of the relationship of the specific gravity of the limb of a young tree to the specific gravity of the bole of the same tree (the juvenile wood referred to above). Three groups of young loblolly pine were sampled. The specific gravity of limb wood samples from 30 trees, each 3, 6, and 9 feet tall, was compared with the specific gravity of the wood of the bole where the limb samples were removed (Fig. 3). Correlations were rather good, in all cases being significant at the 1 per cent level. The best correlations were those for the 3-foot seedlings.

If further work shows this relationship to be reliable, it will enable the researcher to test the specific gravity of seedlings of his crosses or selections by means of a limb, thus leaving the trees to grow. Such a procedure will enable an early assessment of the potential value of the selection and will also make possible an estimate of the specific gravity of the wood of that tree after it has matured. There will thus be established a relationship of limb to juvenile wood and juvenile wood to mature wood.

Genetic Relationships

As stated in the introduction, few concrete results can yet be listed from genetic studies. We have had studies underway since 1951, but the plants established are not yet large enough to give final answers. However, preliminary tests will probably be made within the next few years based on the branch-juvenile wood-mature wood relationship described above.

Genetic studies consist of growing vegetatively reproduced material from trees with extreme specific gravities under relatively uniform conditions to determine if trees with high specific gravity will produce seedlings of high specific gravity while those from low specific gravity trees will produce low specific gravity wood.

Crosses have been made between high and low specific gravity trees, as well as between low-and-low and high-and-high. Open pollinated seedlings from trees of very high or very low specific gravity have been outplanted. A study is underway in which the progeny of a single selfed tree are being tested for wood characters that will be compared to the mother (and father, which in this case are the same) tree. Such selfed material, about 12 years of age, is presently available.

Previously it was felt by some work-

Fig. 3.—A relationship was determined between the specific gravity of the bole wood of a young tree and the specific gravity of the limb near the bole and near the limb end. Best correlations were obtained from the portion of limb immediately next to the bole of the young tree from which it had been removed.

Fig. 4.—The tree with the ladder and the one immediately in front of the man are phenotypically quite similar, are the same age and same diameter, yet have different specific gravities (.56 and .46 respectively).

ers that genetic studies of wood would be rather a waste of time. It has been expressed that wood is a "conservative" character and as such will show little variation within a species group (1). Recently, however, many individuals have recognized that genetic variation might be responsible for some of the differences, or experimental error, so often found. However, little has been done to test this idea.

Rees and Brown (6) reported on specific gravity variations of geographic races within one species. They found a great deal of uniformity within red pine, but did find a "strain" that had wood with a significantly different specific gravity. John Fielding in 1953 indicated that certain clones of Monterey pine have consistently higher specific gravity than others.

This paper has emphasized that a great deal of "circumstantial evidence" has led to the feeling that inherited factors play a recognizable part in the determination of wood specific gravity. Some of this is listed below:

1. When the combined effects of all factors that are commonly accepted as being determiners of specific gravity are assessed (as indicated in the study on environmental and growth variables), they explain only a very small per cent of the total specific gravity variation. Although some workers class the unexplained variation as "experimental error", a considerable portion of it may well be genetic, i.e., inherent in the tree.

2. The maintenance of a relatively high or low specific gravity from juvenile through mature wood in any one tree indicates that some type of inherent pattern may be present.

3. On each plot of 50 trees (even age, uniform site) there was usually a large spread in specific gravities, ranging from very high to very low. This spread was evident on all sites tested, despite geographical location of the plot. This variation was completely confused by age, site, growth rate, and other factor differences. For example, one 31-year-old stand with a growth rate of 5.2 rings per inch had a specific gravity average of .54 while another 28-year-old stand with a growth rate of 5.1 rings per inch had a specific gravity average of only .48. In this case one stand was on a moist, fine sand, while the other was a dry, sandy clay. It is obvious that one cannot arbitrarily say these differences are genetic, even though growth rate and age are similar. But such differences might well be genetic.

4. Often two trees growing side by side could be found that were phenotypically very similar, but which had very distinct differences in specific gravities. On one plot two trees (Fig. 4) were growing within 10 feet of each other, and the roots were intertwined. They were of the same age and had the same diameter. Each was clear of limbs for approximately 65 feet. Yet, one had the highest, the other the lowest specific gravities of all trees on the 50 tree plot. It's difficult to ascribe this difference in specific gravity to growth or environmental factors.

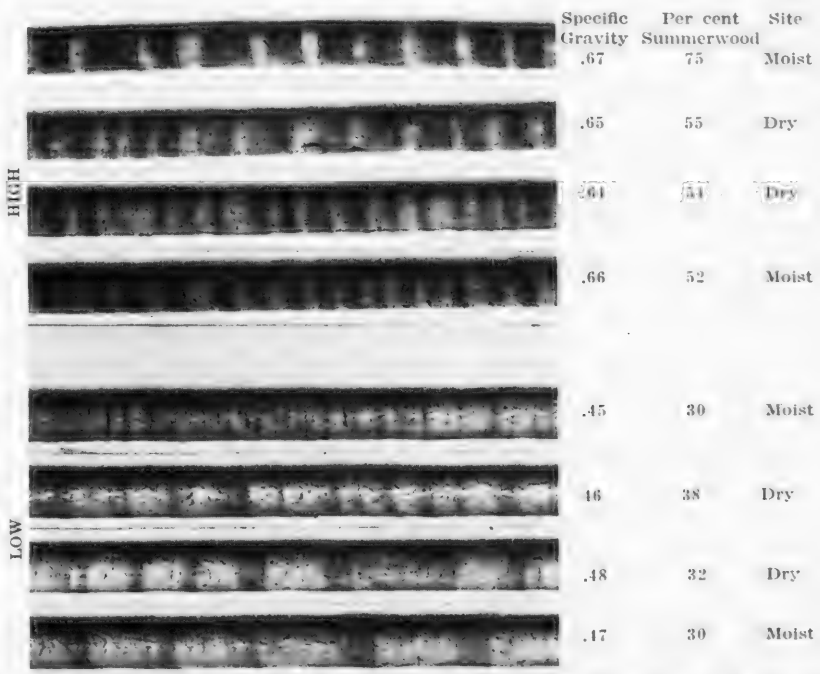

Fig. 5.—Cores taken from high specific gravity and low specific gravity loblolly pine trees.

5. Trees with the most extreme specific gravities were found on different sites and with different growth rates (Fig. 5). This observation prompted the intensive study on environmental and growth factors.

6. Reports by foresters, lumbermen, and pulpwood operators of areas that produce consistently "soft" or "hard" trees (of the same species) are rather common. Often these areas are quite diverse site-wise. They could well represent genetic strains that for some reason have developed within that area. This would be similar to the one "strain" found by Rees and Brown (6) in red pine, one of the most phenotypically uniform species of hard pine known. In a very variable species such as loblolly pine, this could easily happen.

As results of research done under controlled conditions become available, it should be possible to define, within limits, the contribution of genetics to specific gravity determination. That, plus the recognition of the part contributed by growth and environmental variables, should result in a raw product much more uniform in the specific gravity characteristic.

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Discussion

Ernest J. Schreiner[3] (Northeastern Forest Experiment Station, Upper Darby, Pa.): My interest in the heritability of wood specific gravity dates back to 1924 when I started work on the poplar-breeding project of the Oxford Paper Company. One of the first studies required by the company was an investigation of the effect of fast growth on the specific gravity of poplar wood. My own research on this problem between 1924 and 1928, and the accumulation of what Dr. Zobel calls "circumstantial evidence," are in complete agreement with his thesis that the specific gravity of wood is subject to appreciable genetic variation.

Although it is simplest to say that a characteristic is inheritable, this is not sufficiently precise to indicate the factors involved. *It is the potentiality to develop or produce the particular characteristic in response to the effects of internal and external environmental factors that is inherent in living organisms.* The specific gravity of wood is no exception.

But it is not enough to know merely that the specific gravity of wood is the product of heredity and environment. The particular characteristics of living organisms differ widely in their susceptibility to environmental modification. It is, therefore, most important (for the forset manager as well as for the forest geneticist) to know the extent to which the genetic constitution of the tree and the factors of environment, respectively, are responsible for the specific gravity of the wood. The research of Dr. Zobel and his colleagues has advanced our knowledge considerably in this direction.

There are a few contradictory statements of relatively minor importance in the paper under discussion. Point No. 3 in the introduction ("No one growth or environmental characteristic could be found to have a strong influence on specific gravity") contradicts the statement under research results, point No. 4 (". . . a relatively strong relationship was found between specific gravity and per cent summerwood." And further, "But of all variables studied, however, the only one that can be used to estimate specific gravity with any degree of accuracy is per cent summerwood.").

Returning to the paper under discussion, I find that the paragraph on multiple correlation is summarized by the statement: "In other words, a combination of the factors studied could not be used to reliably predict what the specific gravity of any tree would be." It would be more correct to say that a combination of the factors studied does not provide an appreciably better basis for predicting the specific gravity of any tree than the per cent of summerwood alone.

The data on which Dr. Zobel's paper is based (reported by Zobel and Rhodes in Texas Forest Service Tech. Rpt. No. 11) indicates that per cent of summerwood can have a strong influence on specific gravity. The authors conclude that: "The present study shows, in general, a good correlation between summerwood per cent and specific gravity. Thirteen of the fifteen plots showed significance, with an r value as high as 0.8495. Most r values are around 0.5." The r values for five of the plots were statistically significant at the 1 per cent level.

The strongest of Dr. Zobel's "circumstantial evidence" is the fact that in his investigations the eight "growth and environmental factors" account for only a relatively small part of the total specific gravity variation. The unexplained variation is therefore attributable largely to experimental error and genetic variation.

Dr. Zobel's work with loblolly pine is based on a larger number of samples than the earlier research in this country. This relatively large body of data and a good experimental design should reduce the experimental error to a reasonably small percentage of the unexplained variation. But I believe the case he presents for heritability can be strengthened.

Of the eight "growth and environmental factors" studied in this investigation, growth rate, per cent of summerwood (and possibly also per cent of clear bole) are not strictly environmental factors. Growth rate, although highly susceptible to environmental modification is definitely inheritable. Although it accounts for only a negligible part of the specific gravity variance (in these studies), even part of this correlation must be recognized as a genetic effect.

Per cent of summer wood is probably also a subject to the control of one, or probably more, genetic factors. An at present unknown portion of its "relatively strong" effect on specific gravity should therefore be subtracted from the "environmental" side of the ledger and added to the "genetical" side.

The genetics of specific gravity is a complicated problem. It will require the best and most penetrating thinking that we can muster to set up working hypotheses to guide research on this problem to fruitful ends. I have indicated earlier that it is an oversimplifi-

[3] Dr. Schreiner, who is in charge of forest genetics research at the Northeastern Station, was scheduled to present these prepared comments following presentation of the paper but was unable to attend the meeting. The reply by Dr. Zobel, which follows, was submitted after the meeting.

cation to say that the specific gravity of wood is inheritable. Such oversimplified statements may lead to oversimplified working hypotheses.

Specific gravity is obviously not controlled by a single hereditary factor. The length and the diameter of the wood cells, thickness of the cell walls, proportion of springwood and summerwood in conifers (or of fibers and vessels in hardwoods), per cent of cellulose and lignin, and composition and amount of other chemical constituents of the wood, are some of the wood characteristics that, in different degrees, probably determine wood specific gravity.

In respect to these wood characters, it is possible: (1) that they may be controlled by individual genetic factors; (2) that two or more may be under the control of a single genetic factor; (3) that some, such as per cent of summerwood, may depend on more than one genetic factor; (4) that some may be linked, i.e., transmitted as a unit from parent to offspring.

These characteristics are also inheritable; their individual genetic variation may tend to increase or decrease the specific gravity; and they are subject to environmental modification. The specific gravity is therefore the final expression of the effect of environmental factors on the inheritable potential of the individual tree *to produce wood with a number of particular characters.*

Research on wood specific gravity, in my opinion should be planned on the hypothesis that specific gravity is the product of a number of wood characters, each subject to genetical variation and environmental modification, in a plus or minus direction with respect to their effect on specific gravity. On the basis of such a hypothesis, it is not difficult to understand how early research, based on perhaps an unconscious conception of specific gravity as a unity character, and on too few samples, could lead food technologists like Dr. Koehler to the conclusion that ". . . wood is the most 'conservative' part of the tree and therefore least subject to hereditary variations."

Dr. Zobel: Actually, the statements indicated are not contradictory. I said "no one growth or environmental characteristic could be found to have a strong influence on specific gravity." That is what I meant and summerwood per cent, to me, falls neither in the growth or environmental categories. It is a resultant of influences of these on the genetic make-up, just as is fiber length or specific gravity. It is, however, one visible result, short of actual specific gravity determination, that can give a fairly good indication of what the specific gravity will be. Dr. Schreiner said the same thing a little after mentioning the contradictions.

I would also like to add amen and be more positive about Dr. Schreiner's comments on single hereditary factor inheritance. Of course, it has as yet not been proven, but anyone who studies wood and tree characters cannot escape the fact that they, and their inheritance, are complicated. Many things are at work and apparently several genes are involved. It is not a simple case of red or white, of heavy or light. Whether the wood of a tree is heavy or light depends apparently on several factors working together. From what we have seen so far, this appears to be the case in almost all economically important pine characteristics. This fact surely makes the job more difficult — but more interesting, too.

Carl E. Ostrom[4] (Southeastern Forest Experiment Station, Asheville, N. C.): Dr. Zobel has done a real service in bringing the genetic point of view to wood density studies of southern pines. The immediate question raised by his work is the lack of a relationship of specific gravity to age, whereas practically all previous work has indicated such a relationship. The reason appears to lie in the fact that Dr. Zobel was dealing with the wood density along an entire radius in relation to the total age of the tree. In most other studies, a more detailed examination has been made of the relationship of the density of short segments of the ring to the age of ring, or more precisely the age of the tree at the time the ring was laid down. Apparently the relationship of age to density which shows up in these more detailed studies is not strong enough to carry over to the approach used in Dr. Zobel's work.

An excellent recent contribution in this field by D. O. Yandle of the U. S. Forest Products Laboratory indicates that wood density is strongly related to age of ring up to at least the tenth year, but later the relationship of wood density to age of ring and also to width of ring is rather weak. Thus, in a given study of this older wood we might or might not encounter a significant relationship depending entirely upon how well controlled the particular study was. Dr. Zobel's work does support the view that rate of growth is not an all-controlling source of variation in aggregate wood density of southern pines, after one has considered the variation attributable to genetic and other factors.

C. S. Walters (University of Illinois): One point has not been covered, and that concerns the amount of moisture in the soil and its effect on the per cent of summerwood. If you can continue the growth through the summer, you secure a higher per cent of summerwood and increase in the specific gravity. If, however, the soil moisture falls to a point where there is insufficient water, the per cent of summerwood falls and so does specific gravity. I'd suggest that soil moisture measurements be made in future studies of this type.

Dr. Zobel: Soil moisture is not the whole story. All trees do not change from producing springwood to summerwood at the same time. Some change in late spring while others do not until the fall. Making more water available to the latter type tree during the summer will have little effect. Under extreme conditions this seems very true; for example, in California the southern pines apparently produce very little summerwood. Satisfactory growth conditions end there early and apparently such conditions prohibit further growth reducing the summerwood per cent. Excess moisture in the south during late summer often results in the renewed formation of springwood-like tracheids. On the study I just reported on, site moistness was one of the major factors considered. For the 15 areas sampled, no definite correlation could be found between site moistness and specific gravity. If any trend were present, it was for the more moist sites to produce trees with lower specific gravities, an effect opposite to that implied by the question. The key point I feel is the individual tree and *when* this tree changes its wood production. Each tree reacts differently to the same environmental conditions and our hope as geneticists is to find those trees that act very differently—in the direction of the product we want to produce.

[4] Dr. Ostrom, Chief of the Division of Forest Management Research at the Southeastern Station, substituted on the program for Dr. Schreiner (see footnote 3).

The Furniture Manufacturer's Viewpoint on Protection of Furniture for Shipment[1]

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The furniture packaging operation has been revolutionized in terms of materials as well as processes. Progressive furniture manufacturers now employ packaging as a protective device, as a means of merchandising products, and as a definite support in modern furniture production technology. Future outlook for further packaging developments is discussed.

THE PROCESS OF PACKAGING FURNITURE case goods has undergone great change during the past decade. A few years ago, the packaging function consisted largely of wrapping a sheet of kraft paper loosely about the case and then partially confining the very poorly protected case inside a heavy and cumbersome cage made of low grade, rough, and often wet lumber.

The typical furniture package used by the industry in general for several generations up until recent times was a poorly done job, especially when appraised in the light of the minimum standards of the mid-century progressive furniture manufacturer. The great improvement in packaging has gone hand in hand with a marked improvement in the general excellence of case goods. As might well be expected, today's finest furniture rides in today's finest package.

Packaging Revolution

It is interesting to discuss the development of furniture packaging with an experienced case goods packer. This veteran packer describes the packaging revolution almost totally in terms of vast improvements in materials, and the replacement of cumbersome carpentry by planned production methods in the packaging process.

Instead of rough, harsh, often gritty, kraft paper wrapped about the case and a green, wet lumber cage overall, progressive case goods manufacturers now employ a package which lends itself to production methods in its application — which is consistent with good cost practice — which is clean, light in weight and attractive to the eye—a package which keeps the case dry and dust free—a package which can be depended upon to store the product in the manufacturer's warehouse, transport it from the manufacturer to the dealer by rail or truck, and to serve finally as an attractive wrapper to transport the product from the dealer's warehouse to the home of the ultimate consumer.

Within the past few years, more and more furniture and department store dealers in metropolitan centers have come to demand a package durable enough to withstand the rigors of rail and truck travel, and yet simple and light enough to serve as a wrapper for delivery into the home of the urban customer. Quick disposal of packaging materials is a serious problem in cities, so the dealer is extremely interested in a package which may be easily removed and disposed of after delivery. So for this reason and many others, all progressive furniture manufacturers now use package 2–F as described in the Railway Classification Committee specifications or pressure pack as it is better known.

Description of Pressure Pack

Simply stated, the pressure pack is a wrapper of corrugated fiberboard of at least 200 pounds test against breaking strength, over a protective pad of cellulose tissue or other padding material wrapped securely around the finished surfaces to prevent abrasion. A corrugated fiberboard box is very carefully sized so that it may be drawn down snugly around the case with a tolerance approaching zero. A wooden frame constructed of kiln dried, dressed, and carefully sized lumber is used as a skid or a rest for the case and also provides a surface to which the bottom flap of the corrugated wrapper is nailed. The best packers insist upon using corner pads of corrugated board under the box and over the cellulose pad, although railway packaging regulations do not require such pads.

In contrast with old fashioned packs, the pressure pack carton is not fastened to the case. Prior to 2–F days, the framework of the package was nailed or screwed into the back post of the case with frequent disastrous results. It was almost impossible to remove the crating without leaving an ugly scar or a chipped place in the back post.

The modern 2–F package is lightweight and strong and so attractive as to stand in almost ludicrous contrast with the clearance pack or cumbersome lumber crate used until recent days. The 2–F pack allows for no interior crating which may break and move about over the surface of the contents to spoil a fine finish. In contrast, the 2–F package if properly done is virtually abrasion proof because of the soft, absorbent cellulose pad next to the finish.

It is important to note that the 2–F package is a severe test for the finish of furniture, and only the most durable finishes will withstand the pressure pack. Because of the contact between packaging materials and the finished surface, any finishing material other than the most durable top coats will print under the weight of cases stacked one upon the other. Several manufacturers have learned to their dismay that their finish was not durable enough to permit their use of this modern package, and they have been forced to improve their finish in order to use the 2–F package. In short, the general level of quality of furniture finish has been improved because of the use of pressure pack by more and more members of the furniture industry.

Merchandising Device

In order to utilize the package as something more than a protective device, progressive and sales promotion minded manufacturers have made efforts recently to convert the package into a merchandising device. In addition to a constant improvement in the durability of the package, such features as "Zip Strip" or Tear Strip have been added. This innovation allows a tough fiberboard carton to be opened in a manner much like that used to tear the top on a package of cigarettes.

[1] Presented at Session XIII, Packaging, FPRS Tenth National Meeting, June 4-7, 1956, in Asheville, N. C.

The Author: Sam W. Freeman was General Purchasing Agent for the U. of North Carolina during World War II, is now Purchasing Agent for the Drexel Furniture Co.

Fig. 1.—No tools are needed in opening a pressure pack sealed with "Zip-Strip".

At the insistance of progressive furniture manufacturers, the corrugated fiberboard box industry has developed techniques whereby a tough piece of cellulose tape can be fastened inside a carton, near the bottom, so as to permit the slitting of the carton by a firm, steady tug on the tape. In short, and again this is in glaring contrast with the package of a few years ago, a child of tender years can now open a well done 2–F or pressure pack case goods package without any tools. Anyone who has attempted to open an old fashion package made of dry lumber, with cement coated nails or screws, with anything short of a heavy wrecking bar, can appreciate the merits of this new pack.

In cases where manufacturers employ both truck and rail shipment, it is necessary to provide materials for packing all furniture by rail shipment unless the manufacturer can predict accurately how much of his end product will go by truck shipment. Some economies can be realized by predicting the volume of shipments via truck and then packing accordingly. In short, with no regulations to govern truck packaging, definite economies can be made in the cost of boxes as well as innerpack. It is important to note that the heaviest fiberboard and the finest innerpack are no protection against abusive and rough handling.

Endless controversy exists among case goods manufacturers and carriers, both rail and trucking lines, over the matter of mishandling furniture. If furniture manufacturers should attempt to develop a transportation proof package, the cost would be absolutely prohibitive. No pack has ever been devised to offset rough handling to which furniture is subjected, not only by employees of carriers but by personnel in manufacturers' as well as retailers' warehouses. Periodically, we find it necessary at Drexel to refresh memories of our own personnel as well as those of our carriers and our customers of the simple fact that our package is not proof against abuse. Constant attention to such details is probably the only way to keep down the incidence of damage to shipments through mishandling.

Aid to Finishing

Another important aspect of the packaging job which is made more practical by the use of 2–F pressure pack is the recently adopted practice of rubbing and packaging furniture to order. It has been a practice of long standing in the furniture industry to rub and pack furniture as it comes through the production line in the Finishing Room. Thereafter it has been either loaded in railroad cars or trucks or stacked in storage and warehouses. Then, if orders were slow in materializing, packaged goods often sat in warehouses for many weeks or even months before being shipped. It is a well established conclusion that the quality of furniture suffers from long periods of storage in packages. Furthermore, if furniture is rushed through the process and packaged too quickly, careless workmen can hide their negligence in cartons.

So, for a variety of reasons, quality manufacturers now store their goods unrubbed and unpacked and hold it in that state until orders come in. This makes for a great improvement in the rubbing job because aged lacquer rubs to a much better surface than does green lacquer. General quality also is improved by virtue of the cases being stored in full view of anyone who may wish to inspect them. Such practice would hardly be practical under old methods of packaging. Only the pressure pack, which is a production method, can be used in a production process necessitated by this rub-and-ship-to-order method.

Future Prospects

What does the future hold in the way of improvements in the furniture packaging field? It is safe to say that the customer will continue to insist on a better pack—better in terms of protection it affords the product and better in terms of decreased weight with its affect on freight rates.

Possibly the next significant development in furniture packaging will be a pressure pack composed of a thin wrapping of tough paper or plastic over which will be sprayed a fast setting coat of foaming plastic to a thickness of about one-half inch, more or less. This coat will afford cushioning and will keep the product dry and free of dirt in transit. The plastic coat could be stripped from the case at its destination and easily disposed of.

Fig. 2.—Case goods are on skids of kiln-dried, dressed lumber. The pressure pack is not fastened to the case.

Certainly, the furniture manufacturer looks forward to storing packaging materials in form of fluid plastics in tanks rather than in form of mountains of boxes and lumber which take up valuable space in warehouses and which tend to become obsolete.

Or, could it be that rumors of a piggy back system of truck trailers, transported by coastwise ocean freighters from furniture south to New England and to California will materialize in the next few years? Such an eventuality would probably make today's seeming excellent methods and materials obsolete. It has been predicted that such a plan is in process and will materialize within the next two to three years.

Is it practical to imagine that the furniture manufacturer of the future will ship all of his furniture by trucks, wrapped in quilts, at such a reduction in cost that the retailer will be able to provide his own reusable packaging materials for preserving cases in their warehouses?

Will the rumored plan of an alliance among furniture manufacturers and several nationwide chains of home furnishings movers result in expert transportation of unwrapped furniture, with a minimum or with no packaging material with such a cost saving as to eliminate the need for today's packaging materials?

Will the case goods manufacturer of the future follow the lead of many of the big firms in both the case goods and the upholstery industry and use more company owned trucks? Such practice might well result in the elimination of the majority of the materials used today.

The furniture industry solicits your suggestions, both minor and major, for implementing the foregoing dreams or any other improvements of packaging in the furniture industry.

Discussion

G. M. Hill (Drexel Furniture Corp.): Could you give a breakdown of where the damage of furniture in cartons occurs, i.e., in transit, loading out, handling at receipt, etc.?

Mr. Freeman: No. I wish I could give you that information but the facts are not available.

R. F. Weber (Packaging Consultant): Does the furniture industry make use of a so-called "psychological pack" which by its very nature gets gentle handling?

Mr. Freeman: We have not tried such a pack, and I have never heard of it being used in the furniture industry.

Moss B. Christian (Chicago Mill and Lumber Co.): A crate will afford the opportunity to view the contents and thereby cut down the concealed damage.

Tom Luddy (National Wooden Box Association): The National Safe Transit Program offers the shipper the opportunity to pre-test packages in which the package is subjected to the potential hazards of shipping and handling. By testing, inherent weaknesses are disclosed and corrected. Thre are many other advantages offered by participating in this program.

Mr. Weber: I'm sure many in our audience are familiar with the Safe Transit Program. Mr. Freeman, there's no doubt but that the easy opening package will be well received. Does moisture condensation within sealed cartons constitute a problem?

Mr. Freeman: Yes, to some extent. The problems with the finish of packaged furniture held in storage has been attributed by some people to moisture condensation. Mr. Kruger, would you care to comment?

K. W. Kruger (U. S. Forest Products Lab): The Lab has done some work on the effects of condensation in sealed packages. The work has been with metal contents rather than wood, however. We have not heard of condensation being a problem with wood items within sealed containers.

J. C. Anderson (Southern Weighing and Inspection Bureau): The railroads have received some condensation damage claims but not widespread.

Phil Griffith (Cellu–Products Co.): Cushioning pads without backing might help solve the condensation problem.

Mr. Weber: Mr. Hoffman discusses that phase in his paper.

Synthetics vs. Nitrocellulose Lacquers[1]

WILLIAM M. BEAVER

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Reviews general composition and uses of nitrocellulose lacquers and synthetics, low-bake acid catalyzed varnishes. Lists eight factors which should be considered in selecting a topcoat for furniture and compares lacquers and synthetics with respect to these factors.

Introduction

WOODEN FURNITURE is now being manufactured and sold at a rate never before equalled or approached. While much of the sales appeal of furniture lies in construction and design, an equally important part is played by the finish which provides color, depth, build, and durability for the exposed surfaces. The latter two properties are largely dependent on the type of topcoat used in the finishing system. The two most important topcoat materials used in the furniture industry are nitrocellulose lacquers and synthetics.

Nitrocellulose lacquers are well known because of their long tenure in the industry. They have been widely used since the advent of low viscosity nitrocellulose in the 1920's, which made possible the formulation of the so-called high solids lacquers.

Clear nitrocellulose lacquers contain three basic components: nitrocellulose, resins, and plasticizers combined in varying proportions to supply the desired qualities of hardness, adhesion, gloss, and flexibility. These non-volatile materials are dissolved in a solvent system made up of ketones, esters, alcohols, and hydrocarbon diluents. Most furniture lacquers contain from 21 to 35 per cent non-volatile material by weight at spraying consistency, although occasional hot spray formulations may contain as much as 40 per cent.

Lacquers dry by the simple physical action of solvent evaporation. Thus the controlling factors with regard to drying time are the evaporation rate of the solvent and the solvent release of the non-volatile constituents. Naturally the solvent system must be carefully balanced to assure proper flow, freedom from blushing and sagging, and good film integrity.

Synthetics, often referred to as alkyd-urea or low-bake acid catalized varnishes, are not generally as well known or understood as lacquers, although they have been in use for over 15 years. As the name implies, the primary constituents of synthetic varnishes are alkyd and urea-formaldehyde resins. Certain modifiers such as hard resins may also be present.

Alkyd resins are oil modified glycerol-phthlate esters which provide tough, durable coatings but these resins alone do not dry fast or hard enough for the furniture trade. Urea-formaldehyde resins are hard colorless materials possessing a rather strong, unpleasant odor and are quite brittle if not modified. Neither alkyd nor urea-formaldehyde resins are suited as topcoat materials by themselves. However, when they are combined and properly cured, a satisfactory and rather unique furniture finish results.

Alkyd-urea furniture finishes are similar in many ways to the high-bake enamels used in the appliance field. However, since baking temperatures of 300 to 400° F. are not practical with wooden furniture, an acid catalyst is used which in effect takes place of part of the heat. Through the use of these catalysts, low bakes of 1 to 2 hours at 130–150° F. promote a satisfactory cure.

The curing process of a synthetic varnish, unlike a lacquer, is chemical in nature and results in the formation of a complex cross linkage which is induced by heat, oxidation, and catalytic action. The properly cured film is thermosetting and relatively insoluble and, while not as hard or resistant as a high bake metal finish, acid cata-

[1] Presented at Session XII, Wood Finishing, FPRS Tenth National Meeting, June 4–7, 1956, in Asheville, N. C.

The Author: W. M. Beaver received M.S. in organic chemistry from Georgia Tech, has been associated with paint and wood finishing industry for several years.

lyzed synthetics still possess many valuable attributes. Most synthetics contain from 38 to 42 per cent solids at spraying viscosity.

Some synthetic varnishes are being used as room temperature air drying materials. While these are usually satisfactory in certain specific furniture finishing systems, the utmost in film properties cannot be attained without the use of heat.

Since the storage life of synthetics is limited after the addition of the catalyst, it is generally recommended that this addition be made by the user at the time the material is put up to be sprayed. Most synthetics are stable for a period of weeks after being catalyzed. However, in hot weather this stability period is substantially shorter and if not used gelation will eventually result.

In selecting a topcoat for the highly competitive furniture trade, many factors must be taken into consideration. The following are those considered most critically by a prospective user:

1. Ease of handling; sprayability.
2. Fullness and build.
3. Toughness, adhesion, and durability.
4. Speed of dry; print resistance.
5. Color and color retention.
6. Ease of rubbing and clarity.
7. Resistance to water, alcohol, and solvents.
8. Economy.

No attempt is made in the above tabulation to weigh these properties or list them in order of importance, since this will naturally vary according to manufacturing conditions, the type and quality of the furniture being finished, and the opinion of the customer. It should also be recognized that because of the variety of types of lacquers and synthetics on the market, it is not possible to make positive statements which will hold true in every case. Instead this discussion will be general and apply to these materials as a class and as they are being used in the majority of furniture factories at this time. The following will compare lacquers and synthetics with respect to the properties listed above.

Handling and Sprayability

As was previously mentioned, alkyd-urea varnishes possess a rather strong, penetrating odor. Because of this, it is difficult for finishing room personnel to become quickly accustomed to synthetics. However, when ample ventilation is provided, this is usually no great problem.

Because of their low intrinsic viscosity, synthetics spray somewhat easier than lacquers and for the same reason the coverage is usually better. Overspray, fogging, or blushing is not encountered to any extent with synthetics.

Patching, recoating, and general repairing are a little more difficult with synthetics because if done indiscriminately, poor intercoat adhesion may result on recoats due to the insolubility of the cured film. With a little experience techniques can be developed which eliminate or greatly minimize this difficulty.

The addition of catalyst to the synthetic varnish is usually made just before the material is to be sprayed. Catalyst is normally added in the proportion of one gallon to a drum of varnish. It is important that personnel be trained in the systematic and proper addition of the catalyst. If catalyst is not added or the varnish not properly agitated during the addition, improper curing will result. This, of course, can have a serious effect on a day's production. Since no catalyst addition is necessary in the case of lacquers, they can be considered more foolproof from this standpoint.

Fullness and Build

Fullness and build naturally depend on the amount of material applied and the non-volatile content of this material. It is, of course, possible to build up a film of any thickness depending on the number of coats applied. Reducing this subject to more practical terms, one coat of a 40 per cent solids urea varnish is usually the equivalent of at least two coats of lacquer and, in general, ureas tend to have more fullness even at the same film thickness accompanied by a smoother, rubbed appearance.

It is possible with high solids lacquers, generally the hot spray type, to approach the build of a synthetic with one coat. However, it has been found that the most practical high solids lacquers for the furniture trade are those containing from 26 to 30 per cent solids. Higher solids lacquers may give rise to bubbling, poor flow, or may take longer to spray, which can be detrimental on conveyorized systems. In addition, a compromise is made when very high solids lacquers are used in print resistance, color retention, and durability. However, lacquers over 30 per cent solids are being used with good results by furniture manufacturers in many instances.

In some cases where more build is required than one coat of synthetic will provide, a buildcoat is used in conjunction with the synthetic topcoat. This buildcoat may be either lacquer or synthetic but in either case should be used in strict accordance with the manufacturer's instructions in order to avoid adhesion troubles. Synthetics may also be sprayed hot which improves build and flow. Like lacquers, special formulations of synthetics are required for best hot spray results.

Toughness, Adhesion and Durability

These properties, particularly the first two, are greatly dependent on the foundation coats over which the topcoats are applied. The toughest topcoat available may be unsatisfactory if used in conjunction with a poor sealer or improperly dried color coats. As a class, alkyd urea varnishes produce harder finishes than lacquer but by the same token may exhibit poorer adhesion over unsuitable undercoats. When used in properly integrated systems, both lacquers and synthetics of equal quality have toughness and adhesion properties of the same magnitude although lacquers may require longer to reach maximum hardness than force dry synthetics.

The durability of a furniture finish is usually defined in the industry as its ability to resist checking and cracking over a period of years. As might be expected, this property depends not only on the type of finish but also to a large degree on the type of wood over which it is used, whether it be solid or veneer, and its moisture content.

For many years the standard of comparison of durability of furniture finishes has been the cold check test. Because of the many variables involved, this test is somewhat vague and meaningless unless some further qualification is made as to the conditions under which the test is conducted. In spite of this, for convenience in this discussion we can say that a lacquer finish which will withstand over 20 standard cold check cycles is excellent. From the standpoint of durability, even 10 cycles is considered quite satisfactory in most cases since a finish of this quality will usually remain in good condition for the life of the furniture.

It is not possible to refer to durability of a synthetic finish in terms of cold check resistance alone, since for a catalyzed finish other accelerated tests must be used in conjunction with the cold check test. In actual practice, a high quality synthetic will compare favorably with a high quality lacquer system with regard to durability, assuming that substrate, film thickness, and the treatment to which the finish is subjected are equal.

Since lacquers dry by evaporation, they are normally considered a faster drying finish than synthetics. However, in conveyorized systems with force drying facilities, there is little differ-

ence in the drying time of the two materials since a synthetic will dry in 1½ to 2 hours at 130° F. and after cooling may be rubbed and packed without danger of printing. In many instances it is difficult for a lacquer to meet this schedule, especially when several coats have been applied.

In the final analysis, it depends entirely on the manufacturer's equipment as to which may be considered the faster drying topcoat. When adequate heat is available, synthetics have the edge; in air drying systems, lacquers are superior. The drying times mentioned above are minimum satisfactory drying schedules. However, for maximum resistance to shrinkage and printing with either lacquer or synthetics, an overnight drying period with heat is recommended.

Because they are thermosetting, synthetics do not tend to soften and print under conditions of heat and pressure as lacquers occasionally do, especially in warm weather. Printing is therefore seldom encountered with synthetics except when they are improperly cured.

Color and Color Retention

Pale color and good color retention are necessary qualifications which a finishing system must possess if it is to be used on much of the light-colored furniture currently popular.

By the proper selection of resins, plasticizers, and stabilizers, nitrocellulose lacquers can be formulated which are satisfactory for use in practically any application calling for a water white finish. However, under the influence of prolonged sunlight or heat, nitrocellulose itself will decompose to some extent. Some yellowing can be expected from even the best water white nitrocellulose lacquer if conditions are severe enough.

For the ultimate in color retention, synthetics can be formulated which are somewhat superior to nitrocellulose lacquers. This is true because urea-alkyd combinations may be selected which are essentially heat and light stable.

It is important that a water-white finish be well integrated. Care must be taken in the selection of washcoats, sealers, buildcoats, and other components of the system to be sure they will not contribute to the yellowing of the finish. The old adage that a chain is only as strong as its weakest link is quite applicable to furniture finishes. This applies not only to color retention but also to adhesion, durability, dry, and the other properties under discussion.

Ease of Rubbing and Clarity

Regardless of the topcoat used, it is not possible to achieve a high quality rub job without putting a considerable amount of effort into it. It is true, however, that certain finishes lend themselves to rubbing more easily than others. As a class, lacquers are considered by most standards to rub easier and with less effort than synthetics. They also are superior in clarity. Synthetics, being thermosetting, do not soften and flow on the surface of the film under the heat induced by the friction of the rubbing operation. It is this surface flow which gives lacquer a gloss and clarity not easily obtainable with synthetics. In spite of this, synthetics can be rubbed and polished to a high gloss and unless compared directly with a lacquer this lack of clarity is not particularly evident.

Resistance to Water, Alcohol, and Solvents

Lacquers and synthetics are about the same in their resistance to water and alcohol. High quality products are not seriously affected except in instances of severe exposure. In water resistance, a good lacquer may be slightly superior to a catalyzed synthetic although both usually recover satisfactorily from exposure to water and moisture encountered in normal usage.

In resistance to solvents, synthetics have gained widespread popularity since their introduction to the furniture market. The solvents referred to are lacquer solvents such as ketones and esters which, of course, will attack and dissolve a conventional lacquer coating. For this reason synthetics have sales appeal in the field of hotel and hospital furniture where serious damage results from contact with these solvents. It might also be mentioned that because of their lack of thermoplasticity, synthetics are indicated for use in conjunction with alumnium laminated plywood for burn and solvent finishes which approach plastics.

Economy

Cost considerations are of prime importance to any furniture manufacturer. It is extremely difficult in a presentation of this nature to say definitely that one finish is less expensive to use than another. On a cost per gallon basis, synthetics may be slightly higher than lacquers. However, because of the higher solids content of synthetics and their greater coverage, it is less expensive to apply a coating of synthetic than a coating of lacquer at the same dry film thickness. Against this must be balanced the cost of force drying equipment and any other inconvenience which might arise through the use of synthetic varnish.

Summary

An attempt has been made to briefly describe nitrocellulose lacquers and synthetics and compare the characteristics of each which are pertinent in the selection of a furniture finish. It is not the purpose of this paper to single out either as superior over the other since it is obvious that both have desirable and undesirable qualities.

In summarizing synthetics are now firmly established in the industry and no doubt will become more popular as they become more familiar. They possess many outstanding properties such as high solids and exceptional solvent resistance which have increased their sales appeal in recent years.

In addition, most furniture manufacturers equipped with conveyorized force dry systems find that synthetics show economic advantages over lacquer.

Lacquers, on the other hand, are more familiar because of their widespread use and their simplicity and are generally considered more foolproof and adaptable to the average finishing system.

Discussion

J. T. Geoghegan (E. I. duPont Co.): Have you tried masking the odor of synthetics?

Mr. Beaver: Yes, but the odor is still quite pungent. It is mostly a case of becoming accustomed to the odor and having ample ventilation.

J. B. Box (Box Planing Mill and Store Fixture Co.): Is it advisable to use synthetics on top of a lacquer?

Mr. Beaver: Yes. This is common practice. However, the lacquer build coat must be properly formulated so that a well-integrated system results. Caution must be used in applying heavy coats.

A. J. Kirsch (American Cyanamid Co.): Would you elaborate on the air drying time of synthetics?

Mr. Beaver: This depends entirely on the formulation of the synthetic, the amount of catalyst used and the room temperature. However, at best an over night dry is normally required for best results.

Swelling of Paint Films in Water IX. Effects of Temperature During Soaking and Film Formation, and Repeated Soaking and Drying

F. L. BROWNE

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Tests showed that free films of most linseed oil paints, both artificially weathered and unweathered, absorb more water, swell more, and lose more soluble material as the temperature of the water in which they are soaked increases. Higher temperature during formation of films reduces absorption of water and swelling of unweathered films. Coatings of paints on glass continue to absorb water, swell, and lose soluble material when subjected to as many as 15 cycles of soaking followed by re-drying.

Materials and Procedure

FIVE SINGLE-PIGMENT PAINTS made with unbodied linseed oil at a pigment volume of 0.30 were used in the tests. The five pigments were basic carbonate white lead, antimony oxide, rutile titanium dioxide, zinc oxide, and magnesium silicate. Of these, the first two make paints that are low and the last three make paints that are high in absorption and swelling.[2] Antimony oxide was chosen for one of the paints because it seems to have unusual properties. The other four pigments are widely used in commercial paints.

The experimental procedures and methods of calculating results were the same as those described in a previous paper.[3] To make unweathered free films, the paints were spread on gummed paper by doctor blade and suction plate. For weathered free films, the paints were spread on tinplate by doctor blade and suction plate, exposed to artificial weathering for 15 days, and then stripped from the tinplate by amalgamation. Coatings on glass were spread by doctor blade. In all cases, the films were intended to be about 4 mils thick when dry.

After the paints were spread, they were allowed to harden and form films in a laboratory at 70° to 80° F. in daylight from glass windows that face north. Unweathered films were 10 days old when the soaking tests began. Weathered films were 10 days old when placed in the weatherometer for 15 days, and were 26 days old when the soaking tests began.

For films formed at low temperature, the freshly spread paints were placed in a cold room at 36° F. and 80 per cent relative humidity, where they remained in subdued artificial light for three days. At the end of that time, the white lead and zinc oxide paints were thoroughly hardened, the titanium dioxide and magnesium silicate paints were hardened at the surface but still soft underneath, and the antimony oxide paint was still wet.

All of the specimens were then moved to the laboratory at 70° to 80° F., where all paints became thoroughly hardened by the fifth day. For films formed at high temperature, the freshly spread paints were placed in an incubator at 160° F and 20 per cent relative humidity, where they remained in subdued artificial light for three days. They were then moved to the laboratory at 70° to 80° F. When 10 days old, one set of coatings formed at 36° F. and one formed at 160° F. were stripped, cut into films, and started in the soaking test. Other sets of coatings were placed in the weatherometer for 15 days, then stripped, cut into films, and subjected to soaking when 26 days old.

For soaking tests, free films or coatings on glass were submerged in distilled water in crystallizing dishes and held usually at 70° F. in a water thermostat for three days. Exceptions were free films for soaking at 32° F., for which the submerged films were placed in a refrigerator for three days; free films for soaking at 119° F., for which the submerged films were placed in an incubator for three days; and coatings on glass, for which the specimens were immersed in water in a large glass dish at the temperature prevailing in the laboratory (70° to 80° F.).

Temperature of Soaking Water

The first paper in this series[4] reported the effect of temperature of the soaking water on absorption, areal swelling, and solubility of unweathered free films of two kinds of linseed oil paint. Since the effect proved large, it was desired to extend the observations to more paints, to include volumetric swelling, and to study weathered as well as unweathered films.

Results of the new tests on temperature of soaking water are reported in Table 1.

All films, except those of antimony oxide paint and weathered magnesium silicate paint, absorbed much less water when soaked at 33° and much more water when soaked at 119° than they did when soaked at 70° F. Absorption at 119° was from 1.9 to 8.4 times the absorption at 33°. For example, unweathered titanium dioxide films absorbed 6.1 per cent of water at 33°, 26.5 per cent at 70°, and 51.3 per cent at 119° F.

On the other hand, the films of antimony oxide paint and of weathered magnesium silicate paint were relatively insensitive to changes in temperature of the soaking water. Absorption by unweathered antimony

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Browne, F. L. 1955. Swelling of paint films in water, V. Effects of different pigments. For. Prod. Jour. V (3):192-200. 1955.

[3] Browne, F. L. 1956. Swelling of paint films in water, VI. Effect of different oil or oleoresinous vehicles. For. Prod. Jour. VI (4):152-9.

[4] Browne, F. L. 1953. The absorption of water, swelling, and solubility of free films of paint. Jour. of FPRS. III (5):108-24.

The Author: F. L. Browne received B. Chem. degree from Cornell U., Ph. D. in colloid chemistry from U. of Wisconsin. He joined the Forest Products Lab staff in 1918, helped develop casein glues for wood airplanes of World War I. In 1921-22, he was a National Research Fellow at Wisconsin. Since 1929, Dr. Browne has edited the General and Physical Chemistry section of Chemical Abstracts.

Table 1.—EFFECT OF TEMPERATURE OF SOAKING WATER ON THE BEHAVIOR OF FREE FILMS OF UNWEATHERED AND WEATHERED LINSEED OIL PAINTS OF PIGMENT VOLUME 0.30

Pigment in linseed oil, pigment volume 0.30 (density of nonvolatile)	Weight loss while weathering, S_1/V_o	Temperature of soaking water	Density of film: Dry	Density of film: Swollen in water	Density of film: Redried	Initial thickness of film, T_o	Absorption of water, A/V_o	Swelling: In volume, $(\Delta V)_s$	Swelling: In area, $(\Delta Q)_s$	Swelling: In thickness $(\Delta T)_s$	Swelling efficiency, $(\Delta V)_s V_o / A$	Redried: Volume $(\Delta V)_R$	Redried: Area $(\Delta Q)_R$	Redried: Thickness $(\Delta T)_R$	Loss in weight while soaking, S_2/V_o
	Gm. per 100 cc.	°F.				Mils	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Gm. per 100 cc.
FILMS BEFORE WEATHERING															
Basic carbonate white lead (2.70)		33	2.88	2.85	2.91	3.7	2.5	3.0	0.9	1.6	120	-1.8	-0.4	-1.3	1.9
		70	2.87	2.77	2.92	3.9	7.4	7.7	2.7	5.1	104	-2.9	-.7	-2.1	3.6
		119	2.87	2.68	2.94	3.8	14.9	15.6	3.9	10.4	105	-4.3	0	-4.4	6.3
Antimony oxide (2.38)		33	2.56	2.54	2.59	3.7	2.3	2.7	1.6	1.1	117	-1.7	-.8	-.8	1.8
		70	2.55	2.55	2.60	3.9	2.3	2.5	2.7	0	109	-3.2	-.7	-2.6	3.5
		119	2.54	2.56	2.61	3.9	2.8	3.0	2.3	.5	107	-5.2	-2.3	-2.6	6.2
Rutile titanium dioxide (1.91)		33	2.06	2.01	2.08	4.1	6.1	6.9	5.1	1.7	113	-1.4	-1.0	0	1.1
		70	2.06	1.86	2.10	4.1	26.5	27.0	13.5	12.4	102	-3.0	+2.0	-4.9	2.8
		119	2.07	1.73	2.10	4.0	51.3	50.1	25.4	20.6	98	-4.2	+7.4	-10.7	6.5
Zinc oxide (2.33)		33	2.46	2.22	2.48	4.2	21.2	20.7	6.8	12.6	98	-1.3	+.5	-1.7	1.8
		70	2.46	1.89	2.49	3.8	67.5	66.5	21.0	37.7	99	-3.2	+4.8	-7.8	5.5
		119	2.47	1.83	2.41	3.6	80.4	75.2	24.0	40.0	94	-1.6	+9.3	-9.7	9.3
Magnesium silicate (1.51)		33	1.65	1.59	1.67	3.8	11.3	11.9	5.3	6.6	105	-2.0	+.5	-2.1	1.8
		70	1.64	1.47	1.67	4.4	39.7	40.2	14.1	23.2	101	-3.6	+2.4	-6.1	3.6
		119	1.65	1.38	1.67	4.0	70.1	70.4	20.3	41.5	100	-5.7	+5.0	-10.4	7.0
FILMS AFTER WEATHERING															
Basic carbonate white lead (2.70)	11.7	33	3.03	2.98	3.04	3.8	3.3	3.5	1.3	1.8	106	-1.2	-1.1	+.3	1.4
		70	3.04	2.92	3.02	3.9	6.8	5.4	.8	4.6	79	-.2	+.4	-.5	2.8
		119	3.06	2.91	3.07	3.5	10.1	9.1	.7	8.3	90	-1.9	+.1	-2.0	5.3
Antimony oxide (2.38)	30.4	33	2.95	2.94	2.97	3.3	2.9	2.3	1.2	.6	79	-.6	-.4	0	.6
		70	2.85	2.81	2.86	4.4	2.9	2.7	1.6	.9	93	-.7	-.8	+.5	.8
		119	3.04	3.05	3.09	2.7	3.7	2.5	1.8	.7	68	-2.6	-1.1	-1.5	3.8
Rutile titanium dioxide (1.91)	24.7	33	2.34	2.29	2.35	3.2	4.8	4.7	2.8	1.9	98	-.5	-.4	0	.9
		70	2.30	2.22	2.32	3.6	7.6	7.9	3.5	4.8	104	-1.3	-.8	-.8	1.1
		119	2.32	2.23	2.34	3.6	9.1	9.0	4.0	4.7	99	-1.9	-1.8	+.3	2.2
Zinc oxide (2.33)	13.0	33	2.54	2.47	2.56	3.7	11.1	7.6	3.2	4.6	69	-.6	-1.2	+.5	1.0
		70	2.56	2.20	2.56	3.7	40.0	34.1	7.5	24.0	85	-.2	+4.2	-4.0	1.5
		119	2.56	1.97	2.41	3.9	70.7	63.7	20.2	36.0	90	+4.5	+6.2	-1.5	3.7
Magnesium silicate (1.91)	29.0	33	1.84	1.79	1.84	3.8	7.8	7.5	1.8	5.6	96	-.8	+.5	-1.3	1.1
		70	1.84	1.76	1.84	3.5	10.4	10.8	1.3	9.2	104	-1.4	+.9	-2.0	2.1
		119	1.84	1.78	1.85	3.6	9.7	9.5			98	-2.6			3.6

oxide films was 2.3 per cent at 33° and 70°, and 2.8 per cent at 119°; absorption by weathered antimony oxide films was 2.9 per cent at 33° and 70°, and 3.7 per cent at 119°. Unweathered magnesium silicate films absorbed 11.3, 39.7, and 70.1 per cent of water at 33°, 70°, and 119° F., respectively, whereas the corresponding weathered films absorbed only 7.8, 10.4, and 9.7 per cent at the same respective temperatures. The reason for such wide variation in sensitivity of films to changes in temperature of the soaking water is not yet evident.

The density of all films except some of those of antimony oxide paint decreased on soaking approximately in proportion to the amount of water absorbed. Thus the decrease in density was greater at the higher soaking-water temperature. The apparent exception of antimony oxide films is attributable to the fact that the loss of soluble material exceeded the absorption of water by those films that failed to diminish in density.

When the soaked films were redried, they all regained or exceeded their density before soaking except the weathered white lead film soaked at 70° and the weathered and unweathered zinc oxide films soaked at 119° F. The exceptions were films for which low swelling efficiency[5] and low residual shrinkage[6] or even expansion in volume after redrying indicated the development of porosity within the films.

At all temperatures of soaking water, the volumetric swelling of the films paralled the absorption of water. Thus, swelling was much greater at 119° and less at 33° than at 70° F., except for the unweathered and weathered films of antimony oxide paint and weathered films of magnesium silicite paint already noted in the discussion of absorption. Departure from exact parallelism between volumetric swelling and absorption is indicated by the swelling efficiency.

Among unweathered films, swelling efficiency was distinctly higher at 33° and lower at 119° than at 70° F., except for zinc oxide films, for which the swelling efficiency was lowest at 119° but was nearly the same at 33° and 70°. The efficiency was less than 100 per cent for zinc oxide films at all temperatures and for titanium dioxide film at 119°, but was 100 per cent or more for all other unweathered films. Among weathered films, the swelling efficiency was less than 100 per cent for all films except white lead at 33° and titanium dioxide and magnesium silicate at 70° F. There seems to be no consistent relation between swelling efficiency and temperature of soaking water for the weathered films.

When they were redried, all unweathered films and all weathered films except that of zinc oxide soaked at 119° F. shrank to less than the volume before soaking, because of loss of soluble material. The loss in volume was almost directly proportional to the solubility for films of any one paint at the three temperatures, provided that the swelling efficiency gave no evidence of development of porosity in the films.

The slope of the graph relating loss in volume to solubility was nearly the same for unweathered films of antimony oxide and of magnesium silicate paint, but was somewhat less for unweathered films of white lead paint, which suggests that the soluble material from white lead films differs in density from the soluble material from antimony oxide and magnesium silicate films. When one or more of the

[5] Swelling efficiency is the swelling in volume expressed in percentage of the absorption of water by volume. For unweathered films pigmented below their critical pigment volume, the swelling efficiency is usually 100 per cent or slightly greater. Swelling efficiency less than 100 per cent generally means that the film is porous enough to hold some water that causes no swelling.

[6] Loss of soluble ingredients when films are soaked in water usually causes a proportional loss in volume when the films are dried again. But if the films become porous or increase in porosity when redried, the residual shrinkage is less than the loss in soluble ingredients would indicate or there may even be an increased volume after redrying.

Table 2.—EFFECT OF TEMPERATURE DURING DRYING OF LINSEED OIL PAINTS OF PIGMENT VOLUME 0.30 ON THE BEHAVIOR OF FREE FILMS OF THE UNWEATHERED AND WEATHERED PAINTS WHEN SOAKED IN WATER

Pigment in linseed oil, pigment volume 0.30 (density of nonvolatile)	Temperature at which paint dried	Weight loss while weathering, S_1/V_o	Density of film: Dry	Soaked in water	Redried	Initial thickness of film, T_o	Absorption of water, A/V_o	Swelling: In volume, $(\Delta V)_s$	In area, (ΔQ_s)	In thickness $(\Delta T)_s$	Swelling efficiency, $(\Delta V)_s V_o / A$	Redried: Volume, $(\Delta V)_R$	Redried: Area $(\Delta Q)_R$	Redried: Thickness $(\Delta T)_R$	Loss in weight while soaking, S_2/V_o
	°F.	Gm. per 100 cc.				Mils	Percent	Per-cent	Percent	Percent	Percent	Per-cent	Percent	Percent	Gm. per 100 cc.
FILMS BEFORE WEATHERING															
Basic carbonate white lead (2.70)	36		2.86	2.70	2.90	3.8	10.5	10.9	2.6	8.4	104	-2.6	-0.3	-2.3	3.5
	75		2.87	2.77	2.92	3.9	7.4	7.7	2.7	5.1	104	-2.9	-.7	-2.1	3.6
	160		2.95	2.91	2.98	3.8	3.4	3.4	.6	2.9	100	-1.7	-.2	-1.3	2.5
Antimony oxide (2.38)	36		2.56	2.55	2.60	3.9	2.4	2.7	1.9	.8	112	-3.0	-1.6	-1.5	3.2
	75		2.55	2.55	2.60	3.9	2.3	2.5	2.7	0	109	-3.2	-.7	-2.6	3.5
	160		2.60	2.59	2.60	4.1	1.5	1.0	.7	0	67	-.9	-.7	-1.0	2.1
Rutile titanium dioxide (1.91)	36		2.05	1.83	2.09	4.3	28.5	29.4	12.7	15.3	103	-3.2	+2.4	-5.6	2.9
	75		2.06	1.86	2.10	4.1	26.5	27.0	13.5	12.4	102	-3.0	+2.0	-4.9	2.8
	160		2.16	2.15	2.18	3.9	3.1	3.1	2.2	1.0	100	-2.1	-.6	-1.5	2.7
Zinc oxide (2.33)	36		2.46	1.80	2.48	4.2	85.3	84.1	18.1	54.2	99	-3.0	+7.2	-9.6	6.3
	75		2.46	1.89	2.49	3.8	67.5	66.5	21.0	37.7	99	-3.2	+4.8	-7.8	5.5
	160		2.58	2.44	2.59	3.6	10.3	10.2	4.6	5.5	99	-1.1	+.2	-1.4	1.9
Magnesium silicate (1.51)	36		1.67	1.41	1.69	3.8	64.5	64.5	18.0	39.0	100	-3.3	+4.7	-7.8	3.9
	75		1.64	1.47	1.67	4.4	39.7	40.2	14.1	23.2	101	-3.6	+2.4	-6.1	3.6
	160		1.71	1.67	1.71	3.8	6.5	6.4	2.4	4.0	99	-1.9	+.1	-1.9	2.9
FILMS AFTER WEATHERING															
Basic carbonate white lead (2.70)	36	12.6	3.06	2.98	3.04	3.7	5.4	4.0	.4	3.6	74	-.3	-.3	+.3	2.6
	75	11.7	3.04	2.92	3.02	3.9	6.8	5.4	.8	4.6	79	-.2	+.4	-.5	2.8
	160	10.2	3.12	3.00	3.04	3.7	5.3	4.7	.4	4.6	85	+1.9	-.6	+2.7	1.9
Antimony oxide (2.38)	36	32.5	2.90	2.86	2.91	3.0	2.4	2.7	1.9	1.7	112	-.8	-.8	0	1.0
	75	30.4	2.85	2.81	2.86	4.4	2.9	2.7	1.6	.9	93	-.7	-.8	+.5	.8
	160	19.0	2.90	2.87	2.91	3.2	2.6	2.5	2.0	.3	96	-.5	-.6	0	1.3
Rutile titanium dioxide (1.91)	36	20.3	2.30	2.23	2.30	3.4	5.3	5.9	3.3	2.4	111	-1.1	-1.3	0	1.1
	75	24.7	2.30	2.22	2.32	3.6	7.6	7.9	3.5	4.8	104	-1.3	-.8	-.8	1.1
	160	10.7	2.28	2.24	2.30	3.8	4.4	4.6	2.8	1.9	105	-1.1	-1.3	0	.9
Zinc oxide (2.33)	36	10.9	2.59	2.30	2.59	3.7	28.0	25.0	5.6	18.0	89	-.3	+1.3	-1.3	1.1
	75	13.0	2.56	2.20	2.56	3.7	40.0	34.1	7.5	24.0	85	-.2	+4.2	-4.0	1.5
	160	7.6	2.68	2.54	2.67	3.5	10.2	9.4	2.1	7.1	92	0	-.4	+.6	.3
Magnesium silicate (1.51)	36	32.8	1.84	1.80	1.87	3.1	6.2	7.0	2.0	5.1	113	-2.3	+.1	-2.6	1.7
	75	29.0	1.84	1.76	1.84	3.5	10.4	10.8	1.3	9.2	104	-1.4	+.9	-2.0	2.1
	160	27.7	1.89	1.84	1.90	3.0	6.0	6.5	2.4	4.3	108	-1.9	-.4	-1.7	2.0

films of any one paint became porous when it was redried, the relation between loss in volume and solubility was no longer linear, as was to be expected.

The changes in area and thickness of films during soaking and redrying were related to the changes in volume in much the same manner that was observed in previous studies.

All films, without exception, yielded less soluble material to the soaking water at 33° and more soluble material at 119° than at 70° F. The temperature coefficient of solubility was therefore positive in all cases. For the unweathered films, the coefficient ranged from 0.051 to 0.087, and for the weathered films it ranged from 0.015 to 0.045 gram per cubic centimeter of film for each degree of temperature.

Temperature During Formation of Films

Practical experience with house paint has long indicated that paint coatings are affected adversely by low temperature and high humidity during the period of hardening after the paint has been spread and that, conversely, coatings may be improved if the hardening takes place at temperatures somewhat higher than usual. It was therefore desirable to determine how the temperature during film formation affects the subsequent behavior of the films when they are soaked and redried.

Results of the tests with films formed at different temperatures are reported in Table 2.

The absorption of water by unweathered films was always greater for films formed at 36° and less for films formed at 160° than for films of the same composition formed at 75° F. For antimony oxide films, which did not harden during the three days at the lowest temperature, the differences were slight and the absorption was small at all three temperatures.

All other unweathered films absorbed much less water when formed at 160° than at 75°, and usually absorbed much more when formed at 36° than at 75°. Thus, zinc oxide films absorbed 85.3, 67.5, and 10.3 per cent of water when formed at 36°, 75°, and 160° F., respectively. No film formed at high temperature absorbed more than 10.3 per cent of water. After the films had been weathered, however, the absorption fell to approximately the level of the unweathered films formed at 160° except for the zinc oxide paint, for which weathered films formed at 36° and 75° still absorbed more than twice as much water as the film formed at 160° F. Thus, formation of films (other than those of zinc oxide) at 160° seems to have much the same effect on absorption as weathering.

Formation of films at 160° F. caused a distinctly greater increase in density over that of the nonvolatile components of the paint than occurred during formation at lower temperatures, but films formed at 75° were little if any greater in density than those formed at 36°. Weathering always caused a further increase in density in which the advantage of films formed at the highest temperature over those formed at the lower temperatures was retained by all paints except titanium dioxide.

Loss in weight of films during weathering was always less, usually markedly less, for films formed at 160° than for those formed at 75° or 36° F. The density of the films diminished approximately in proportion to the amount of water absorbed, but was regained or exceeded when the films were redried, except for weathered films of white lead and the film of zinc oxide formed at 160° F. The exceptional films all had low swelling efficiencies that were indicative of porosity.

For unweathered films, the volumetric swelling was nearly equal to the absorption of water; that is, the swelling efficiency was nearly 100 per cent. The greater deviations from 100 per cent by the antimony oxide films

cannot be considered exceptions because absorption and swelling were too low for an accurate calculation of efficiency. For weathered films of white lead and of zinc oxide, the swelling efficiency was always less than 100 per cent, but for films of titanium dioxide and of magnesium silicate it remained somewhat more than 100 per cent. The temperature at which films are formed therefore seems to have little or no effect on swelling efficiency. Similarly, the temperature at which films are formed does not appear to alter significantly the usual pattern of behavior with respect to shrinkage and distribution of the volumetric changes between area and thickness.

The solubility during soaking was about the same for unweathered films formed at 36° as for those formed at 75°, but was always somewhat less for those formed at 160° F. Among weathered films, decreased solubility for films formed at 160° was found in the cases of white lead, titanium dioxide, and zinc oxide paints, but not in those of antimony oxide and magnesium silicate paints.

Repeated Soaking and Drying of Bound Films

Paint coatings bound to a non-swelling substrate such as glass cannot swell or shrink in length or width and must accomplish practically all their volumetric changes by change in thickness alone. It was shown previously[7] that such constraint reduces the absorption and swelling of bound coatings to about four-fifths of the changes in corresponding free films. Presumably the constraint develops greater internal stresses within bound coatings than within free films. It seemed desirable to learn whether repeated reversal of the internal stresses tends to disrupt the structure of coatings with consequent increase in porosity.

It was also of interest to learn whether all soluble material is leached from coatings during the first few soakings in water. Bound coatings were more suitable for these tests than free films, both because of the greater internal stresses and because free films often curl too much or become too fragile for repeated soaking tests.

Results of the tests of repeated soaking and redrying of coatings on glass are reported in Table 3. All specimens were subjected to 15 cycles of soaking in distilled water for three days, followed by drying for two to five days. Complete sets of weighings and measurements were made during each of the first five cycles, during the tenth cycle, and during the fifteenth cycle. Data for the third and fourth cycles are omitted from Table 3 because they follow closely the trends from the second to the fifth cycle. There was, of course, a lapse of about 90 days from the beginning of the first to the end of the fifteenth cycle. The last two columns of Table 3 record the cumulative or overall changes in volume and weight of the coatings from the beginning of the first to the end of the fifteenth cycle.

The density of 10-day-old coatings was always reasonably close to that of 10-day-old free films of the same paints in Table 1. During the soaking tests with unweathered coatings, the density usually increased as soluble material was lost from the coatings. The unweathered zinc oxide films, however, gained in density during the first cycles, after which their density decreased and their swelling efficiency gave evidence of a marked increase in porosity.

Weathered coatings either decreased in density appreciably (zinc oxide), decreased slightly (white lead, magnesium silicate), remained unchanged (titanium dioxide), or increased very slightly (antimony oxide) during the 15 cycles.

The change in density depended on the extent to which the loss of soluble material was offset by gain in volume by the development of porosity. The density always decreased for both unweathered and weathered coatings when they were soaked, and it was regained or exceeded when they were redried unless the coating failed to shrink as much as its combined loss in volume of water and of soluble material.

Among the unweathered coatings, the absorption of water by white lead and by antimony oxide remained at nearly the same low levels and the absorption by magnesium silicate at nearly the same high level throughout the 15 cycles of soaking and redrying. The absorption by coatings of zinc oxide or of titanium dioxide, however, was significantly greater in the first or in the first and second cycles than in subsequent cycles, but leveled off to a relatively constant absorption for the later cycles, which for the zinc oxide coating at least was still high. Weathered coatings of all paints changed very little in absorption during the 15 cycles.

The swelling efficiency of both unweathered and weathered zinc oxide coatings showed the expected downward trend from the first to the fifteenth cycle of soaking and redrying. This, together with the downward trend in density and the slight cumulative shrinkage or expansion in volume after redrying, clearly reveals an increasing porosity of the coatings during the progress of the cycles.

Weathered coatings of white lead and perhaps of antimony oxide showed a similar downward trend in swelling efficiency, but the unweathered coatings did not. Likewise, weathered coatings of titanium dioxide and of magnesium silicate fell below 100 per cent efficiency by the fifteenth cycle, although they were still above 100 per cent at the tenth cycle. The unweathered coatings of titanium dioxide and of magnesium silicate remained above 100 per cent efficiency through the 15 cycles.

The evidence indicates, therefore, that zinc oxide coatings, even before weathering, tend to become steadily more porous with each cycle of soaking and drying, and that weathered coatings of most paints also become porous if the cycles are repeated often enough.

Unweathered coatings lost more soluble material in the first cycle of soaking than in any later cycle. Nevertheless, there was always a further loss in each additional cycle that became nearly constant in amount after the fifth or at least by the tenth cycle. If all of the soluble material were present in the 10-day-old coatings before the first soaking, there should be a steady decrease in solubility from cycle to cycle until all soluble material was removed. It may be concluded, therefore, that solubilization goes on continually in the unweathered coatings as a result of advancing age or hydrolysis while in contact with water.

Weathered coatings yielded less soluble material than unweathered films in the first soaking in water. From the second through the tenth cycles, the solubility of weathered coatings was approximately the same as that of the corresponding unweathered coatings, but by the fifteenth cycle, the solubility of weathered coatings fell to 0 to 0.3 gram per 100 cubic centimeters of coating. It is therefore possible that still further repetitions of the cycles would bring the weathered coatings to a point at which no further soluble material could be extracted, but the persistence of losses through at least 14 to 15 cycles indicates that solubilization continues to go on for some time after the soluble matter present before the first cycle has been extracted.

The last two columns of Table 3 show that all unweathered coatings suffered a cumulative loss in volume and loss in weight during the 15 cycles of soaking and drying. Except for the zinc oxide coatings, the loss in volume was only slightly less than the loss in

[7] See footnote 2.

weight, as would be expected if the loss in volume was due entirely to loss of soluble material of density only slightly greater than 1. For the four paints other than zinc oxide, the density of the soluble material indicated by the ratio of weight loss to volume loss was between 1.07 and 1.21 that is, it did not exceed the density of hardened films of 10-day-old unpigmented linseed oil. Such concordance of weight and volume losses, together with swelling efficiencies generally above and seldom far below 100 per cent, indicates that the coatings of the four paints were able to swell and shrink repeatedly without serious impairment of their internal structure.

Unweathered coatings of zinc oxide, however, lost only 1.6 per cent in volume for a weight loss of 10.8 grams per 100 cubic centimeters. The ratio of weight loss to volume loss was 6.7, more than 2–½ times the density of the paint coating when 10 days old. Since zinc oxide paints yield significant quantities of zinc salts to the soaking water, the density of the soluble products from such paints is probably higher than that from most other paints, but it must be far short of 6.7. Thus, the high ratio of weight loss to volume loss of the zinc oxide coatings confirms the development of porosity indicated by low swelling efficiency.

Since the swelling efficiency was 96 per cent in the first cycle, when the loss of soluble material was 4.8 grams per 100 cubic centimeters, and fell off strikingly in subsequent cycles, when the solubility remained fairly constant at 0.4 to 0.6 gram per 100 cubic centimeters, it seems reasonable to conclude that the stresses from repeated swelling and shrinking impaired the internal structure of the zinc oxide coatings and was at least partly responsible for the development of porosity.

Among weathered coatings, those of white lead and of zinc oxide gained slightly in volume by the end of the fifteenth cycle. Coatings of the other three paints lost volume, but the loss was much less than that of the corresponding unweathered coatings, and the ratio of weight loss to volume loss was 2.0 to 3.1. By the fifteenth cycle, the swelling efficiency of weathered coatings was always less than 100 per cent. It seems, then, that the internal structure of all of the weathered coatings was damaged in a manner causing porosity by repeated swelling and shrinking.

All test specimens of white lead, antimony oxide, and titanium dioxide coatings remained firmly adherent to

Table 3.—REPEATED SOAKING AND REDRYING OF COATINGS OF LINSEED OIL PAINTS OF PIGMENT VOLUME 0.30 ON GLASS BEFORE AND AFTER WEATHERING

Pigment in linseed oil, pigment volume 0.30 (density of nonvolatile)	Number of cycles of soaking in water and redrying	Weight loss while weathering, S_1/V_o	Density of coating: Dry	Soaked in water	Redried	Initial thickness of coating, T_o	Absorption of water, A/V_o	Swelling in volume, $(\Delta V)_s$	Swelling efficiency, $\frac{(\Delta V)_s V_o}{A}$	Redried volume, $(\Delta V)_R$	Loss in weight while soaking, S_2/V_o	Total change, first to fifteenth soaking: In volume	In weight
		Gm. per 100 cc.				Mils	Percent	Percent	Percent	Percent	Gm. per 100 cc.	Percent	Gm. per 100 cc.
COATINGS BEFORE WEATHERING													
Basic carbonate white lead (2.70)	1		2.87	2.82	2.90	3.7	4.6	4.4	96	-1.1	1.1		
	2		2.90	2.82	2.92	3.6	5.0	6.1	122	-1.5	.5		
	5		2.94	2.85	2.94	3.5	4.9	4.6	94	0	.4	-3.8	-4.1
	10		2.92	2.82	2.94	3.6	4.6	5.3	115	-1.0	.4		
	15		2.94	2.85	2.94	3.5	4.2	4.6	109	-.3	.3		
Antimony oxide (2.38)	1		2.52	2.50	2.53	3.8	2.7	2.1	78	-1.5	2.3		
	2		2.53	2.50	2.57	3.7	2.6	3.5	135	-1.7	1.0		
	5		2.57	2.53	2.57	3.7	2.1	1.8	86	+.1	.4	-6.1	-7.4
	10		2.55	2.53	2.58	3.7	2.6	3.2	123	-1.8	.6		
	15		2.59	2.55	2.61	3.6	3.0	3.3	110	-.8	.6		
Rutile titanium dioxide (1.91)	1		2.07	1.90	2.09	3.9	20.7	20.3	98	-2.9	3.5		
	2		2.09	1.92	2.12	3.8	20.7	21.2	102	-2.1	1.1		
	5		2.14	2.00	2.14	3.6	14.4	13.8	96	-.1	.7	-10.4	-11.1
	10		2.15	2.01	2.17	3.6	14.3	15.2	106	-1.4	.7		
	15		2.18	2.04	2.18	3.5	12.7	12.9	101	-.6	.6		
Zinc oxide (2.33)	1		2.45	1.96	2.49	3.8	57.8	55.6	96	-3.2	4.8		
	2		2.49	2.18	2.50	3.7	28.8	27.0	94	-.6	.5		
	5		2.47	2.19	2.45	3.7	28.8	25.4	88	+.6	.5	-1.6	-10.8
	10		2.38	2.15	2.41	3.8	29.8	25.8	87	-1.1	.4		
	15		2.36	2.18	2.39	3.8	29.6	22.9	77	-1.3	.6		
Magnesium silicate (1.51)	1		1.67	1.52	1.68	3.7	29.6	29.3	99	-2.3	3.2		
	2		1.68	1.53	1.70	3.6	27.5	28.6	104	-1.8	1.0		
	5		1.70	1.55	1.70	3.5	27.7	27.3	99	-.7	1.0	-10.3	-12.1
	10		1.70	1.54	1.72	3.4	31.3	31.8	102	-1.4	.7		
	15		1.73	1.56	1.73	3.3	30.6	31.0	101	-.5	.7		
COATINGS AFTER WEATHERING													
Basic carbonate white lead (2.70)	1	11.4	3.10	2.98	3.03	3.3	5.5	6.0	109	+2.4	.6		
	2		3.03	2.98	3.04	3.4	6.0	4.1	68	-.4	.7		
	5		3.04	2.97	3.02	3.4	5.8	4.2	72	+.6	.6	+.1	-5.5
	10		3.05	2.96	3.04	3.3	5.0	4.3	86	+.2	.5		
	15		3.04	3.01	3.06	3.3	4.6	2.9	63	-.4	.2		
Antimony oxide (2.38)	1	31.2	2.98	2.92	2.97	2.9	3.7	3.6	97	0	1.2		
	2		2.97	2.91	2.99	2.9	3.9	4.0	102	-1.1	.9		
	5		2.98	2.91	2.96	2.9	4.0	3.3	82	+.2	1.0	-3.2	-7.1
	10		2.99	2.90	3.00	2.9	4.7	4.9	104	-.7	.6		
	15		2.98	2.95	3.01	2.9	3.5	2.9	83	-1.0	.1		
Rutile titanium dioxide (1.91)	1	22.3	2.34	2.21	2.34	3.1	9.7	10.2	105	-.4	1.1		
	2		2.34	2.20	2.34	3.1	10.8	11.7	108	-.5	.3		
	5		2.33	2.18	2.31	3.1	11.5	11.4	99	+.2	.8	-1.4	-2.8
	10		2.33	2.18	2.33	3.1	11.7	12.4	106	+.1	.1		
	15		2.32	2.21	2.34	3.1	11.2	11.0	99	-.8	0		
Zinc oxide (2.33)	1	13.2	2.69	2.43	2.67	3.3	17.4	17.7	102	+.6	.1		
	2		2.67	2.39	2.63	3.4	19.7	19.6	99	+1.3	.1		
	5		2.64	2.38	2.62	3.4	20.1	19.0	95	+.5	.7	+.9	-5.0
	10		2.64	2.37	2.63	3.4	20.0	19.7	98	+.6	.2		
	15		2.56	2.33	2.56	3.5	19.4	18.2	94	-.3	.3		
Magnesium silicate (1.51)	1	27.8	1.87	1.76	1.87	2.9	12.1	12.9	106	-.7	1.4		
	2		1.87	1.76	1.87	2.9	13.4	14.3	107	-.3	.6		
	5		1.86	1.75	1.84	2.9	13.0	13.0	100	+.4	.6	-1.1	-3.4
	10		1.85	1.74	1.85	2.8	14.8	15.2	103	0	.4		
	15		1.85	1.77	1.86	2.9	12.9	11.8	92	-.4	.1		

the glass and free from blisters throughout the 15 cycles of testing. Half of these coatings had already withstood the preliminary weathering. Unweathered coatings of zinc oxide developed a few small blisters in the first soaking test, when the solubility was 4.8 grams per 100 cubic centimeters. The blisters disappeared when the coatings were redried and did not appear in subsequent soakings, when the solubility never exceeded 0.7 gram. Weathered zinc oxide coatings developed no blisters at any time.

Both weathered and unweathered coatings of magnesium silicate became blistered in the tenth cycle. The blisters disappeared when the films were redried but they appeared again in each subsequent cycle. The blisters were somewhat larger on the weathered than on the unweathered test specimens. Unweathered coatings of zinc oxide and of magnesium silicate began to come loose along the edges of the test specimens by the end of the fifth cycle. The loosened area increased during subsequent cycles but had not progressed beyond 5 to 10 per cent of the total area of contact between coating and glass at the end of the fifteenth cycle. The defects of blistering and loosening of coatings were confined to the paints with the greatest degree of swelling.

Conclusions

Most paint films, both before and after weathering, absorb more water and swell more when soaked in warm water (119° F.) and absorb and swell less when soaked in cold water (33° F.) than when soaked in water at 70° F. Films of antimony oxide paint are exceptions to the rule because they take up a little more water and swell a little more at 119° than at the lower temperatures.

The quantity of soluble material extracted from films of any one kind of paint is nearly proportional to the temperature of the soaking water, at least for the unweathered films. The temperature coefficient of solubility for unweathered films ranges from 0.051 to 0.087 gram per cubic centimeter of film for each degree of temperature Fahrenheit. Moreover, when films that give no evidence of porosity are redried, the volumetric shrinkage beyond the volume before soaking is almost directly proportional to the solubility at the different temperatures.

The slope of the graph relating loss in volume to solubility seems to be nearly the same for unweathered films of chemically inert pigments (antimony oxide and magnesium silicate) but is slightly less for unweathered white lead films. At 70° F., the ratio of solubility to loss in volume indicates that the soluble material from white lead films has a density of 1.2 and the soluble material from antimony oxide or magnesium silicate film has a density of 1.1.

The temperature prevailing during the formation of paint coatings (first three days after spreading) greatly affects the absorption of water and swelling of free films cut from the unweathered coatings of most paints. The most striking effect is that of high temperature of formation (160° F.) on paints that are high in absorption and swelling when formed at 70° to 80° F.

None of the paints tested absorbs more than 10.2 per cent of water when the coating is formed at 160° F. For the highly absorptive zinc oxide, magnesium silicate, and titanium dioxide paints, this is less than one-sixth of their absorption when formed at 70° to 80° F. Formation at 160° F. reduces absorption and swelling of titanium dioxide and megnesium silicate as much as does 15 days of artificial weathering, and reduces the absorption and swelling of zinc oxide paint considerably more than does weathering.

Although temperature as high as 160° F. may be attained at times on parts of houses exposed to full sunshine during hot days within a month or so of the summer solstice, practical painting can hardly be confined to such times and places even in the southern part of the United States. Nevertheless discovery of the marked improvement in highly absorptive paints by high temperature during hardening suggests that other and more practicable means might be found to accomplish the purpose.

Antimony oxide paint is not significantly improved by formation at high temperature, but its absorption and swelling are very low at all temperatures.

Formation of coatings at low temperatures (36° F.) increases the absorption and swelling of unweathered films markedly for zinc oxide and magnesium silicate paints, and slightly for titanium dioxide, white lead, and perhaps for antimony oxide paint. After weathering, however, the effect of low temperature during formation is no longer observable.

Data for repeated soaking and redrying of unweathered and weathered coatings of zinc oxide paint on glass give evidence of a disruption of the internal structure and development of porosity from the stresses involved in swelling and shrinking while two of the three dimensions of the coating remain fixed by its attachment to the glass. A loosening of the coatings from the glass along edges of the test specimens after a few cycles of test with unweathered zinc oxide gives further evidence of stress.

Unweathered coatings of white lead, antimony oxide, titanium dioxide, and magnesium silicate paints on glass withstand 15 cycles of soaking and redrying without evidence of serious impairment of structure, but weathered coatings begin to show disruption of structure and porosity if the cycles are repeated often enough. Unweathered coatings of magnesium silicate paint begin to loosen from the glass at edges of the test specimens after a few cycles, and both unweathered and weathered coatings of magnesium silicate paint become blistered during each of the later soaking periods.

Although unweathered coatings yield more soluble material in the first cycle than in later cycles, the solubility remains nearly constant after a few cycles and is appreciable for at least 15 cycles. Solubilization apparently goes on continually either from aging or from hydrolysis because of contact with water. Weathered coatings contain less soluble matter at the outset than unweathered coatings. Solubilization continues for many cycles but may ultimately cease after 15 cycles or more.

From the ratio of the cumulative loss in weight to loss in volume during 15 cycles for unweathered coatings that seem to retain unimpaired internal structure, the density of the soluble material lies between 1.1 and 1.2.

Forest Products Research and Industrial Development[1]

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Discusses the need for research to achieve the goal of optimum development and utilization of forest resources. A balanced program of fundamental research, applied research, and industrial development is necessary to reach this goal. The role of TVA in furthering industrialization and conservation of resources in the Tennessee Valley is described.

CHANGE AND PROGRESS are the life blood of the forest industry. No company, corporation, or area can stand still for long. Either it goes forward with new developments and expanded markets, or backward into bankruptcy and oblivion. When the results are tallied, research in forest products is the essential prescription for keeping the industry healthy and lusty. Without it anemia sets in and weakness becomes evident. Thus, when speaking of the objectives of forest products research, one is discussing something of deep concern to every progressive forest industry and of still greater concern to the ultra-conservative, non-progressive, dying companies.

The reasons for the recently aroused interest in forest products research are obvious. In the interest of survival, capital must be spent in finding new products, additional uses for waste, and better and more efficient ways of carrying out the various operations. Not only must each industry look to its own future, but there is a certain responsibility for all of the industry to participate in finding these new products, better ways, and more economic methods which will make forest products cheaper and of greater usefulness to the consumer.

Essentially, the objective of products research is the production of the greatest economic values from the forest resource—from trees to residue. If this is achieved it will lead to greater profits for the company, more taxes and support to the Government, more jobs to more people, and a better economy all around.

Heavily forested states such as Kentucky and Tennessee have a greater stake in such research because, to a considerable extent, their economies are dependent upon the forest industries for doing their share toward optimum industrial development and economic improvement. The activities of the Forest Products Research Society in stimulating this research and development are highly appreciated by states which are greatly dependent upon the forest resource.

We should take a good look at the research program as it is now developing to see whether it is adequate to achieve the goal of optimum development and utilization of the forest resource. It is not enough that we learn how to make new products, how to use the tree better, or how to make forest products at less cost. All of this is useless unless the results are utilized by industry.

To learn how to manufacture newsprint from southern pines and hardwoods might be a satisfactory final objective for the research specialist, but actually it means little unless plants can be economically built and this better, lower-cost product begins to flow into the life stream of the economy. In this case, research has already resulted in the establishment of newsprint mills at Lufkin, Texas; Coosa Pines, and Mobile, Alabama; and Calhoun, Tennessee; and probably will result in the construction of additional plants. Only when this happens has research reached fruition.

This means that fundamental research in the field of forest products, applied research, and the development of industry are inseparably tied up and the success of one depends upon the success of the others. Balanced effort is necessary in fundamental and applied research to the point of industrial development. Such a balanced program needs support right down the line for the good of the industry in the long run. This could be accomplished either by balanced company programs or by support to cooperative efforts at AFPI, colleges, or the U. S. Forest Products Laboratory.

The opportunity for industrial expansion in the forest industries presents some intriguing research possibilities. Not only can the forest be made more productive but much more of the raw material taken from the tree can be used.

As an illustration, Fig. 1 shows the situation close at hand in Kentucky and Tennessee. W. W. Jolly of our staff has worked out on this chart[2] the present and potential forest economy for a million acres in Tennessee. In this state the forest industry is a $270 million business. Under optimum development and adequate markets, it could eventually, without increasing the forest acreage, turn out in the neighborhood of four times the value of products it does today. This could be done on the basis of research already carried out. In other words it would involve no new products—merely the manufacture of each board foot of growth into some product for which it is suited.

In Kentucky industrialization is not yet as highly developed, as can be seen on Fig. 2 headed "Value Added by Manufacture." The total industry which now produces products in excess of $100 million could, if as productive as the million-acre example in Tennessee, produce in the neighborhood of $800 million worth of products. This leaves a great deal of room for industrial development.

The achievement of such an objective in the state of Kentucky would, of necessity, be a longtime project. In his report on the industrial possibilities of the forest resource of Kentucky,[3] George W. Hubley, Jr., points out that the yield of primary forest

[1] Presented at meeting of FPRS Ohio Valley Section, May 13, 1955, in Louisville, Ky.

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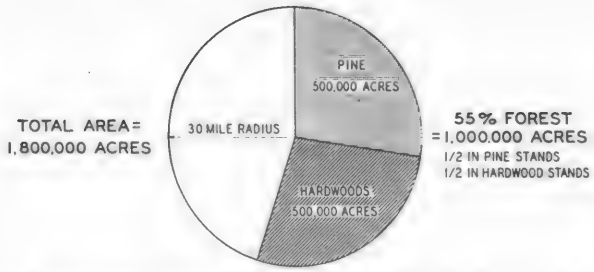
[2] From talk on "Tennessee's Forest Products Industry and its Potentialities" presented by W. W. Jolly at Keep Tennessee Green Association, April 7, 1955.

[3] Industrial possibilities of the forest resource of Kentucky. George W. Hubley, Jr., Executive Director, Agricultural and Industrial Development Board of Kentucky, Frankfort, 1953.



ITEM	PRESENT	POTENTIAL
GROWTH PER ACRE OF FOREST	110 BOARD FT	375 BOARD FT PINE RATE: 500 BOARD FEET HARDWOODS RATE: 250 BOARD FEET
SAWMILLS OTHER WOOD PROCESSING PLANTS	300 82	10 97
PINE LUMBER CUT HARDWOOD LUMBER CUT	50,000000 BF 20,000000 BF	250,000,000 BOARD FEET 125,000,000 BOARD FEET
THINNINGS AND WASTES:		
PINE	20,000 CORDS	575,000 CORDS {450,000 CDS-THINNINGS; 125,000 CDS MILL WASTES}
HARDWOODS	10,000 CORDS	320,000 CORDS {250,000 CDS-THINNINGS; 30 000 CDS-TOPS; 40,000 CDS-MILL WASTE}
VALUE OF PRODUCTS:		
PINE LUMBER	$ 2,600,000	$13,900,000
HARDWOOD LUMBER	680,000	6,250,000
OTHER WOOD PRODUCTS	28,300,000	67,750,000
TOTAL	$31,580,000	$87,900,000

Fig. 1.—Economic potential of 1 million acres of forest in Tennessee.

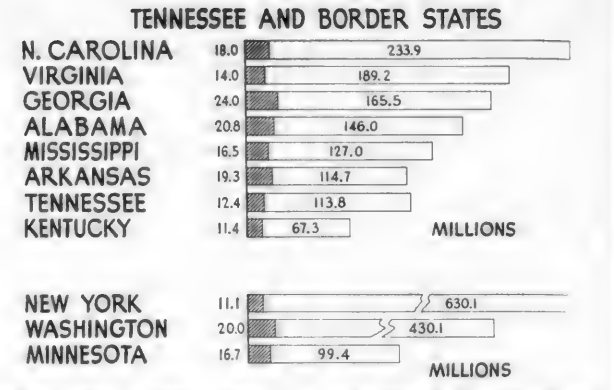


Fig. 2.—Value added by manufacture by forest products industries.

products alone, which were valued at $42 million in 1949, could be increased to at least $180 million through stand improvement and raising the growth rate to the highest possible level. The introduction of new secondary manufacturing plants would be necessary to achieving the optimum goal.

Perhaps we might ask why Kentucky is the only Southern state without a pulp mill. There may be many impediments to the full development of the forest industry. Lack of natural resources may not always be the most serious. Certainly, there is no lack of resources in Kentucky, which has a surplus of pine growth at the present time and a very large surplus of hardwood growth—mostly in the lower grades. Note New York on Fig. 2. Here development has been achieved because of extensive markets and good transportation which make possible the processing of much imported raw wood.

Lack of markets could be a real hindrance. So, also, is lack of good transportation facilities and high freight rates. Pulpwood rates are a case in point, and it would be interesting to review the pulpwood rate case for the southern territory—ICC Docket #30958—in this connection. Other important factors are water supplies, adequate power, labor supply and organization, community facilities, and capital. All need to be carefully analyzed to determine local programs which might be necessary to encourage industrial development.

In the Tennessee Valley, for example, this is being done as a part of the cooperative resource development program resulting from TVA's primary program interests in flood control, navigation, and the development of hydroelectric power. As a spur to the economy and to further industrial development and the conservation and optimum use of resources in the Tennessee Valley, the TVA has over the past 22 years developed control of floods along the main stem of the Tennessee River, has built a navigable waterway with a nine-foot channel from Paducah to Knoxville, and has developed a dependable supply of electric power. These improvements provide the basic physical essentials for industrialization. It means that many good industrial sites free of floods with a supply of clean water in large dependable quantities are available on the reservoirs. These sites are now close to major sources of power, many having barge, rail, and truck transportation.

There is a responsibility on the part of TVA to see that the fullest use of these resources is encouraged for the improvement of the social and economic well-being of the region and for national defense. In the case of forestry, we are fully cognizant of this responsibility in the Forestry Relations Division. More particularly, in our forest utilization and economics research, we are seeking facts which can be made available to the states and to industry which will assist in appraising local industrial development problems. Many facts are needed and it is here that statistics on the many phases of the forest resource problems are necessary.

The forest products industries are largely resource-based and because of this it is essential that county data regarding the forest resource and its utilization be available. We have set up our program to reach each Valley county once every ten years.

In our plan for utilization research for the next five years, we propose to give particular stress to the low-grade hardwood problem and explore the possibilities of utilizing low-grade hardwoods from hardwood and mixed pine areas which are being converted to pine by various methods. We are also stressing studies in logging and milling residue utilization and are keeping in close touch with present utilization methods, both in logging and milling, in order to obtain information which might be used in improving the economy of this industry.

We have many requests from planning agencies and industries for assistance in industrial planning and are particularly fortunate in having within the TVA organization various specialists who contribute to our investigations. For example, in one analysis concerning the establishment of a pine pulp and paper mill in the Tennessee Valley,[4] data on freight rates, delivered prices, pulpwood landings and transportation facilities, natural gas rates, and property tax information were collected by experts in our Commerce Department. Water analyses were prepared by our Health and Safety Division, power rates by the Office of the Manager of Power, tables on possible flood conditions at potential plant sites by the Water Control Planning Division, and additional tax information by the Regional Studies Division. The foresters provided the forestry information.

This teamwork is necessary in any industrial development analysis. Many fields of specialty need to participate if the information resulting from for-

[4] Factual data for use as a basis for determining the practicality of establishing a pine pulp and paper mill in the Tennessee Valley—Analysis of possible sites. Department of Forestry Relations, Norris, Tennessee, December 1955.

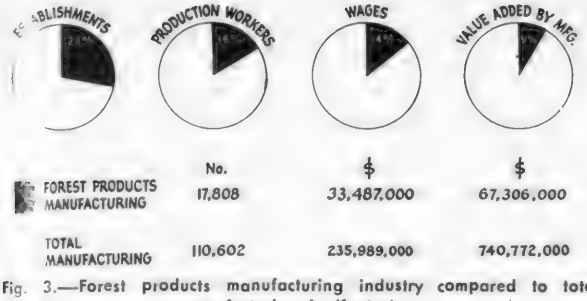


Fig. 3.—Forest products manufacturing industry compared to total manufacturing in Kentucky.

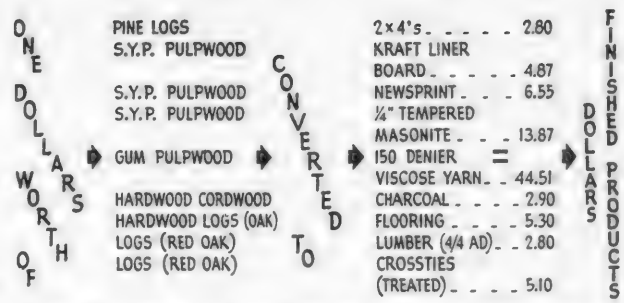

ONE DOLLARS WORTH OF
PINE LOGS
S.Y.P. PULPWOOD
S.Y.P. PULPWOOD
S.Y.P. PULPWOOD
GUM PULPWOOD
HARDWOOD CORDWOOD
HARDWOOD LOGS (OAK)
LOGS (RED OAK)
LOGS (RED OAK)
CONVERTED TO
2×4's 2.80
KRAFT LINER BOARD 4.87
NEWSPRINT . . . 6.55
¼" TEMPERED MASONITE . . . 13.87
150 DENIER VISCOSE YARN . . 44.51
CHARCOAL 2.90
FLOORING 5.30
LUMBER (4/4 AD) . . 2.80
CROSSTIES (TREATED) 5.10
DOLLARS FINISHED PRODUCTS

Fig. 4.—Dollar conversion values for various forest products.

est products research is to be used in industrial development. It makes no difference whether your corporation sets up a team to solve a plant location problem or whether such analyses are being prepared by local development boards, state development boards, railroad industrial agents, or others who are interested in promoting industry. The team approach is the key which will unlock the results of forest products research so that it may be used as it was meant to be used—to achieve the full use of resources and full economic development.

Perhaps the Forest Products Research Society should consider this need and develop some type of organization. Perhaps a forest industry development committee could assist the states, industries, and local organizations in carrying out their responsibilities in the field of forest industry development, could cooperate with industries seeking new locations, and do many other jobs which would breathe life into forest products research so that the results may be of increasing benefit to the economy.

Sample locational studies could be developed. State and federal agencies could be encouraged to make specific studies. Opportunities could be pointed out to industry and to local planning groups and state and local chambers of commerce. There are many possibilities in this field.

The Forest Products Research Society has a good cross-section of expert opinion able to analyze and present the facts. This should be a part of our activities if we believe that the pay-off in forest products research is in industrial development. If we believe this, we should consider the problem and determine what can be done to translate research results into factories, jobs, and other economic good necessary to the building of strong economies in our forest regions.

Materials of Construction Related to Fire Insurance Costs[1]

JOHN W. MORRIS, JR.

Division Engineer, South-Eastern Underwriters Association, Atlanta, Ga.

Factors determining fire insurance rates for buildings are discussed. Combustibility of materials is only one of many factors involved and all interrelated factors must be considered in establishing fire loss probability. Insurance rates are not necessarily a predominant influence in selecting construction materials.

THE COST OF FIRE INSURANCE on a property is usually expressed in terms of dollars per $100 of insurance and is referred to as a "rate". Thus, with a rate of $1.50, the cost for each $100 of insurance is $1.50 for a term of one year.

If the statement were made that wood is combustible and fire insurance costs on buildings are directly proportional to the amount of combustible material used in construction, such a statement would seem quite logical. Such a statement, however, may be quite misleading and would be actually incorrect in many specific cases since there are numerous other factors which must be considered.

The objective sought in establishing fire insurance rates is to equitably determine the cost of fire insurance on one property according to its probable fire loss as compared to the probable fire loss on all other property. The probable fire loss on all property, within a geographical area, if the number of properties be sufficiently large, may be determined with reasonable accuracy by actual experience over a period of years, providing the factors causing the losses remain reasonably constant. In order to utilize information on fire experience and project probable fire loss on various types of property, the property type must be defined or classified.

Historically, for fire insurance purposes, buildings have been classified as frame, brick, and "fireproof", frame buildings being of wooden construction; brick buildings being of exterior brick walls with wooden floors and/or roof; and fireproof (or fire-resistive) buildings being of reinforced concrete throughout.

With the advancements made in the science and art of building construction and with the use of new materials and innovations in methods of assembly, numerous modern buildings do not fall entirely within any of these basic historical classes. Hence the assembled materials must be specifically evaluated.

Classes of Materials

Materials of building construction may be classified into three broad classes: first, combustible, such as wood; second, noncombustible which does not burn but which is susceptible

[1] Presented at meeting of FPRS Florida-Georgia-Alabama Section, May 12–13, 1955, in Savannah, Ga.

The author: J. W. Morris, Jr. is graduate of U. of Virginia and the Insurance Institute of America. He has been employed by South-Eastern Underwriters Assoc. for past 25 years, is chairman of National Fire Protection Association committee and member of Society of Fire Protection Engineers.

to severe damage when exposed to fire, such as steel; and third, fire-resistive, which is noncombustible and which will withstand moderate fires without appreciable damage, such as reinforced concrete.

These broad classifications of materials, however, are subject to further qualifications as new material combinations are developed and used in building construction.

For example, wood may be impregnated with water-soluble chemicals to reduce combustibility; wood shavings may be mixed with cement or gypsum to form a precast unit; wood or vegetable fiber may be laminated with noncombustible material or coated with fire-retardant paint; Underwriters' Laboratories-listed fire doors may have wooden cores. Should these products be considered combustible?

To assist in arriving at the answer, a standard "Tunnel Test" has been developed, known as ASTM No. E84. In this test a panel of the product is subjected to a flame under standardized conditions and the relative surface flame spread, the BTU contribution, and the developed smoke is determined as compared with concrete taken at zero and red oak taken at 100.

This test is of assistance as previously indicated, but it does not give the entire answer as to combustibility. The National Board of Fire Underwriters has issued a definition of "Noncombustible" as applied to building construction materials using the surface flame spread as one criteria. This definition is now in rather wide use for many purposes.

Another test of materials of construction, known as the retardant test (U. L. 263; ASA, A2–1; ASTM Serial E 119), is widely used for many purposes. In this test, wall and floor panels and columns are subjected to a rapid temperature rise (1,000 deg. F. in 5 minutes; 1,700 deg. F. in one hour) and may be subjected to water from a standardized hose stream at the end of a specified period. Performance as to the transfer of heat to the unexposed surface of a panel and ability to properly sustain designed live and dead loads are expressed in terms of hours. Thus, we may have an assembly of one-hour fire resistance or four-hour fire resistance.

The classification of the behavior of materials of construction, either as to its combustibility or fire-resistance is valuable information in the determination of fire insurance rates. However, these factors are interrelated with many others.

Other Factors

The probable fire loss of an individual property as reflected in its fire insurance rate is based on many components, the broad divisions of which include the building structure, the class of occupancy, the efficiency of interior and exterior fire protection, and exposures, together with the various stipulations which may be made in the insurance contract. Each component is so interrelated that a change in one may affect a change in the evaluation of any of the others.

Theoretically, these variable components of probable fire loss may be infinitely expanded; however, there are practical limits to the number which can be used.

For example, there are now generally in use the three broad classes of building construction: frame, brick, and fire-resistive; some 115 different classes of occupancy; and some 10 different classes of public outside fire protection. There are many variations of interior fire protection which may be automatic or non-automatic.

Each of these interrelated classifications may be further modified according to the specific case under consideration. For example, it is possible for a building structure to be classified as "fire-resistive" but because of other components of fire loss probability may actually have a fire insurance rate equal to or greater than some other building classified as "brick" or "frame". Conversely, a building may be classified as frame, but because of other components of fire loss probability may have a fire insurance rate equal to or less than another building classified as "fire-resistive" or "brick".

In the selection of materials of construction for a building, a property owner may be motivated by many influences, such as artistic beauty, functional design, probable time of use of an intended occupancy, cost of the completed structure, depreciation, safety to life of occupants, building code requirements, and probable loss from fire as reflected in the fire insurance rate. While the fire insurance rate may be a contributing influence, there are many specific cases where this influence is more or less immaterial. It is quite doubtful that all of these influences will remain a constant throughout the useful life of the building. Fire insurance rates for specific classifications are under continuous study. They have not been constant in the past and there is no reason to think they will remain unchanged in the future.

Whether the owner of a building of combustible construction wishes to be insured against the loss by fire at a rate which represents an equitable fire loss probability or whether a specific insurance company wishes to decline such insurance or limit its liability because of large area or high values, is a matter of contractual choice or both.

Conclusions

From the foregoing brief generalities, which it is believed represent the opinion of the majority of people in the fire insurance business, it appears reasonable to draw the following conclusions:

(a) Although buildings may contain combustible materials of construction, this feature is but one of many in the determination of the fire loss probability and may or may not be a predominant factor.

(b) The extent to which the use of combustible materials of construction in a specific building will affect its fire loss probability as reflected in the fire insurance rate can only be determined by a thorough study of the specific case, taking into consideration the numerous other factors.

(c) The determination of the fire loss probability of all types of fire insurance classifications is under continuous study and may be decreased or increased within the period of the useful life of any specific building.

(d) The choice of the use of any materials of construction for a building may be influenced by the probable fire loss as reflected in the fire insurance rate but the fire insurance rate is not necessarily a predominant influence in the choice.

How Research Can Aid the Architect in Specifying Forest Products[1]

PANEL DISCUSSION

Areas where architects and forest products industries should cooperate are pointed out and several specific problems are presented concerning use of wood in building construction. Discussed are product improvement, style trends, use of wood in large buildings, building codes, non-standard products, and need for product research.

PROBLEMS OF COOPERATION between practicing architects and the forest products industries were discussed by a panel representing the Washington State Chapter of the American Institute of Architects and the Forest Products Research Society. Discussion moderator was Dr. O. Harry Schrader, Jr., General Manager, U. S. Plywood Corp., Seattle.

Dr. Schrader: Members of FPRS have felt that a better liaison should exist between architects, as users of forest products, and those who produce and sell these products. It is a pleasure to have such a representative group here. Each of these men will present a particular aspect of the field, based on his experience and observations.

IMPROVING THE PRODUCT

Francis E. Huggard (Architect, Seattle): The architect finds several faults with wood materials delivered for use on the job.

Grain raise. Most plywood is sanded before leaving the manufacturer. On the job, it must be sealed and stained, or finished in some manner, often resulting in grain raise. This requires hand sanding, an expensive operation. Could this be eliminated by applying stains and sealers at time of manufacture, followed by machine sanding where necessary? The same is true of finished lumber.

Damage to corners. It is often noticed that plywood panels have corners sanded thin. Could plywood be sanded first and trimmed later? Plywood also suffers from damage to corners in handling. Could this be remedied with a protective corner piece?

Length variations. Often lumber is not true to length. Studs in particular are too long and require resawing.

Modular construction. In this type of construction, the center line of studs is used as the point of origin and should be marked for carpenters.

Fireproofing. Fireproofing of lumber is important and would widen its use. Fire rules attempt to eliminate combustible materials.

Advertising. Most promotional work is not directed toward the architect.

STYLE TRENDS

David R. Anderson (Architect, Seattle): How can the architect keep up with and direct style trends? Each user and each dealer has a part in this. Advertisements affect style trends and what the customer wants, particularly in residential construction. Wood, as a building material, has a warmth in homes and churches not available in other materials.

Fire retardency is important. It can be obtained reasonably well by applying materials currently available, but these affect later staining of the wood. Molded plywood is as yet undeveloped in the fields of furniture and exterior uses. Kiln drying of lumber in large dimensions is not yet done but such products are very desirable.

Although not related to style, builders are not familiar with grading rules. (It was pointed out in the Discussion period that the purchase of W.C.L.A. or D.F.P.A. grade-marked products would obviate this difficulty.)

FOREST PRODUCTS IN LARGE BUILDINGS

John S. Detlie (Architect, Seattle): There is a modern trend in the use of wood in large buildings. Several suggestions are offered to improve this utilization of timber.

Laminated beams and timbers. The appearance of these products is too standardized. It is necessary to make them of Douglas-fir as the standard for strength, but why cannot there be a choice of skin or veneer covering? Although hemlock is not yet used, its lighter tone gives a more desirable appearance than does fir. Long spans are becoming more common, making advantageous the use of laminated timbers.

School buildings. Steel manufacturers provide economical joist systems. Lumber manufacturers need to produce a joist system that is easily handled and with an attractive appearance. Joist hangers should have an aesthetic value and not require to be hidden.

Restrictions. Architects need the support and help of wood products manufacturers on building code revisions. Why should wood panels be excluded from public buildings, especially when they have been treated with fire retardents?

BUILDING CODES

Nelson S. Perkins (Douglas Fir Plywood Assoc., Tacoma, Wash.): A building code may be defined as the law that admits or prohibits types of construction or materials. There are three national codes set up by building officials:

(a) The Uniform Code of the Pacific Coast Building Industry. This is 30 years old, and has 450 adoptions.

(b) The Basic Code of the Building Officials. This code has been used for 6 to 7 years in the East and Northeast.

(c) The Southern Building Conference Code.

A fourth national code is the National Building Code of the Insurance Underwriters Association, which is a code mainly adopted by small towns.

Numerous municipal building codes have been set up for local conditions, based on one or other of the national codes.

Each of the above groups have advisory committees whose function is to recommend on acceptances and revisions. The Douglas Fir Plywood Association and other industry associations make representations to the advisory groups, using research data from the

[1] Outline of panel discussion presented at a meeting of the FPRS Pacific Northwest Section, Feb. 1955, in Seattle, Wash.

U. S. Forest Products Laboratory, the National Bureau of Standards, and university laboratories. It is more difficult to deal with the local boards whose members are usually more reactionary than are members of the advisory committees.

Building codes are based on safety, life, and public health, and not economics.

PRODUCING NON-STANDARDIZED PRODUCTS

G. Eugene Tower (Forest Fiber Products Co., Forest Grove, Ore.): Lumber and plywood are examples of products that have been standardized, whereas hardboard provides an example of a product that is not standardized. How does such a product become standardized? The viewpoint expressed is that of research and product development in a small company. First is the idea stage.

Many ideas come from salesmen in the field as to new uses for a product and as to new products themselves. The manufacturer must then follow the general procedure of:

1. Making laboratory checks as to the properties of a board to fit the intended use.
2. Making a market survey of architects, retailers, and builders, as to the use of a product and the problems of its use.
3. Making a pilot plant operation to produce the product.
4. Testing market acceptance.
5. Working the product into plant production.

The manufacturer must know the limitations of his products. It is only through the use and improvement of a product that it can become accepted as a standard material.

PRODUCT RESEARCH

Robert W. Petterson (St. Paul & Tacoma Lumber Co., Tacoma, Wash.): My company has produced lumber for 67 years and plywood for 10 years. It has maintained its position by continually producing and marketing new products. The company has a technical service department, the main function of which is to do research and development. Product research is the most pressing problem.

The development of specialty products to enter new markets often makes the entry of the company's standard products possible. An example of a specialty product is our pre-cut, wide lap siding with a paper overlay. It is our belief that the use of high density overlays is not fully exploited. There are many other examples available of industry-developed new products.

Discussion

E. W. Wellwood (Canadian Forest Products Ltd., New Westminster, B. C.): In general, for commercial and industrial buildings, is a 4′ x 8′ plywood panel suitable for exterior facing where appearance is paramount?

Mr. Huggard: Plywood is not usually suitable for exterior facings.

Mr. Wellwood: Do architects consider the plastic-faced plywood panels as part of the answer to the pre-sealing problem?

Mr. Perkins: Prompt priming and good paint, with edges sealed, give good results. Plastic surfaced plywood is better, and takes 20 per cent less paint.

R. W. Young: How and in what form should new product information be presented to architects, and of what value are samples with the initial presentation?

Mr. Huggard: Data should be on 8½ by 11-inch sheets for standard files. Personal contact is the best means of presenting new product information. Plant trips are also good, and seminars to show uses and applications.

Harold Evans (Plywood Research Foundation, Tacoma, Wash.): You mentioned a need for price information. It is difficult for a manufacturer to publish prices because they vary with geographic areas, and because of price fixing laws. Would a general retail price be sufficient with a qualifying range of $10/M sq. ft. or f.b.m.?

Mr. Huggard: The British base prices on the installation costs of a standard unit, which are then related to local conditions by a conversion factor. This would seem to be a satisfactory arrangement.

Question: In designing homes do you specify so-called stock window units or do you design custom built units? Would you like to see stock window units further finished than just toxic treated?

Mr. Anderson: Many contractors now use aluminum frames which require no finishing. Where wood windows are specified they come untreated or with a toxic dip. Obviously the contractors prefer a stock unit requiring a minimum of finishing.

Question: Do you consider dry lumber for home construction sufficiently important to justify a premium price?

Mr. Anderson: Yes, otherwise it involves air drying at the job if the shrinkage problem is to be avoided. This is more serious for large sizes than for the sizes that are usual in home construction.

Mr. Evans: Have you found that most of your customers wanting houses will pay extra in order to have warm wood interior paneling or wood exteriors (roof and side walls), that is, providing they like wood in the first place?

Mr. Anderson: Yes.

D. H. Clark (Wash. State Institute of Forest Products, Seattle): What is your reaction to specifying native red alder for flooring, paneling, and ceiling? What information would you require from producers of such products before you would be willing to specify them on residential buildings?

Mr. Anderson: We are willing to specify a new material where we have adequate data on its performance and where we consider its use advantageous.

Question: How is the manufacturer to always know the end use of his products?

Mr. Detlie: Agencies have been created to keep architects up-to-date in their fields. Perhaps the same should apply to manufacturers.

A. T. Walton (Simpson Logging Co., Shelton, Wash.): Isn't the answer to problems of end use more than just what new products can forest industries come up with? We tend to assume that the functions of a product in a house or structure are clearly defined. In many cases the lack of communication between manufacturer and architect leads to misuse. On this basis the problem should be restated as "What can all people involved in housing do to produce a better product at less cost."

Question: In timbers and dimension do architects always specify the sizes actually necessary? In our experience there have been requests for grades and sizes that are very hard to meet.

Mr. Detlie: Architects are well aware of sizes available. Most design is for function and use. The use of glued-up members has been a boon to the architects.

E. W. Wellwood: From your experience with building codes, is it your opinion that eventually plywood and hardboard to be used in commercial buildings will have to be treated to make them at least fire-resistant?

Mr. Perkins: The answer is not known but such treatment would increase the markets available to these products. Economics or costs are a problem.

Question: In getting a new product on the market, how is FHA approval related to building code acceptance?

Mr. Perkins: FHA has an entity of its own and its requirements are essentially a building code.

Question: Is anything being done to improve Reject grade plywood so that the do-it-yourself trade will have better material at a lower cost?

Mr. Perkins: "Shop-cutting grade for remanufacture only" is the new name for Reject grade. Rejects are

suitable for many uses where the bond is satisfactory, as is usually the case. No manufacturer wants to produce rejects as they are a fall-down grade.

Question: Should companies do their own research and therefore not have to share results, i.e. not depend on public laboratories for basic results?

Mr. Petterson: Companies should do product research but not basic research.

Question: Do institutions know what products or materials are marketable?

Mr. Petterson: Not always. The manufacturer is the best judge.

Fibreboard Furniture Packages[1]

JETER D. EVANS

District Sales Manager, Corrugated Box Division, The Mengel Co., Winston Salem. N. C.

History and development of fibreboard furniture packages are traced. Predetermination of furniture package durability by testing is discussed in detail. Testing methods described include: Mullen test, vibration test, drop test, Conbur incline impact test, puncture test, and compression test.

ANY TALK ON FURNITURE PACKAGES would not be complete without at least a brief history of their development. Prior to 1930, corrugated box sales to furniture manufacturers were pitifully small. Their usage was limited to night stands, benches, chairs, and a few other small items. One isolated manufacturer on the West Coast was trying boxes on case goods.

In the early 1930's a few furniture manufacturers in this area became interested in some substitution for the old, heavy, wood crate. The first efforts were a somewhat dismal failure. On trial shipments which were followed to New York, New Orleans, and other points, a sad condition presented itself when the merchandise reached destination—damage galore and an utterly spoiled finish. We had not reckoned with a soft finish and what might happen with the tremendous heat that generates within a box car.

The next attempt was with a suspension pack—one which would permit the article to remain clear from contact with the inside walls of the box. Through no fault of the container, there still was a problem with the finish itself. Even in storage, high humidity caused sweating which resulted in discoloration to soft finishes.

About the same time, a manufacturer in South Carolina and one in North Carolina began experimenting with pressure packs. The South Carolina man simply used kraft wrapping paper and top corner protectors made from corrugated board. The North Carolina manufacturer bought old newspapers by the truckload, using several thicknesses as the padding to protect his finish. Both firms made small, apartment-size furniture. Fortunately, and this is important, both used a hard lacquer finish. Their results were excellent, and we certainly learned something about marking or printing trouble.

At this stage the short bottom flaps in connection with the wood skid and the use of big-headed nails for closure came into being. These were the forerunners of the present-day furniture packages.

Simultaneously, the big stores in the metropolitan areas were clamoring for a prepack. There was formed the National Furniture Pre-Pack Association. This group consisted of the large department stores and a few self-appointed boxmakers whose goal was a packaged product which could be delivered right into the customer's home. This program made some headway, but was not totally successful because the furniture manufacturers were more or less by-passed in the initial planning.

From the very beginning when certain groups said that corrugated board would never do the job and that only the old wooden crate could be used, we have continued our program with one thought—safe transportation. Many so-called specialists thought along the lines of extra high test board, say 350 lb. Mullen Test. But there is no Mullen Test of the openings in a wood crate.

At that time there were actually no strict regulations as to how furniture must be packed. About the only requirement was that the packing be adequate to insure safety in transit. The carriers, of course, were certainly cognizant of their mounting claims and something had to be done about them. Surely, something would have been done sooner, but World War II came along with its inevitable shortages and the situation concerning quality and damage became worse.

First Packing Specifications

While the carriers never relaxed in their efforts to draw up a set of specifications, it was not until early in 1948 that the railroads finally published specifications governing the packing of all items of furniture. These were and are the "F" packages. Much thought, experience, and work went into this evolution. It could not have been done without the joint efforts of the best experts in transportation, packaging, and manufacturing.

There have been those who would be critical but the classification committees did a tremendously good job. There had to be a starting point somewhere. Despite the fact that some of the requirements appear a little stiff, the committees who wrote the details are to be commended on the terminology which permits flexibility and gives some leeway in its interpretation and application. Certain phraseology has been condemned as not being clear and of being ambiguous. Of course, the language is not that of the layman but legal documents are not intended for the layman. This is where the know-how comes to the front.

Of the original 30 or so F packages, many have been added to, some strengthened, and many changed to fit certain situations. This is always done by publication of a supplement to the classification—and only after thorough hearings in public docket meetings.

No furniture manufacturer is interested in selling his merchandise to the carriers as damaged goods via the freight claims department. All of them take great pains to see that their product is made well. Unbounded care is exercised on the finish and the styling. Certainly, such attention is exerted with the idea of selling this article to some customer. A great percentage of

[1] Presented at Session XIII, Packaging, FPRS Twenty-Fifth National Meeting, June 4–7, 1956, in Asheville, N. C.

the damage for which the carriers have paid was done by some amateur carpenter who tried with a crowbar, a pair of pliers, and a screw driver to get into one of those old-fashioned crates. Have you ever tried with a screw driver to withdraw a screw which had been put in with a power-driven tool? Now with the disposable fibreboard packages and the easy-opening devices which are in use, any man, woman, or child can do the job without putting a scratch on the furniture.

Testing Methods

The American Association of Railroads Testing Program for furniture maintains in Chicago a National Safe Transit Testing Laboratory which is available to the manufacturers. Articles of furniture can be sent there for testing free of charge.

The first step is placing the packaged product on a vibrating machine. This equipment is simply a platform with staked ends which is geared to an electrical motor to produce forward and backward pitch, simultaneously giving an up and down motion. The particular motion simulates the over-the-road action of a carrier—the constant movement and the sudden shifts and thrusts are almost identically duplicated. One hour of vibration is the required standard. This is an accelerated test—one hour on the machine is the equivalent of a 250-mile trip in a box car or truck traveling 50 miles per hour.

Next the article is subjected to the Conbur impact test. The equipment consists of a heavy wooden dolly on which the package is placed. The dolly is mounted on wheels which run on a metal track. The track is elevated at its back end to provide an incline. When the dolly is raised to the desired mileage marking, it is released. Immediately, it travels down the track and, with great force and much noise, crashes into a heavy bulkhead. This action is similar to car humping or the sudden stops experienced in truck transportation. The procedure calls for five bumps to each end of the package with the furniture standing on its feet. Then the article is placed on its back with the base section at 45° angle to the bulkhead. It is impacted once from each end. This sounds rugged but all too often a piece of furniture has to be unloaded from a tailgate or a platform. Sometimes there is no other way except to drop it.

The final step is at the standard drop-tester. Here the package is raised at one end to a height of 12 inches—the other end resting on the floor. Each end of the article is dropped five times.

If the merchandise comes through these tests, the package is all right. Amazingly, much of it does come through.

We maintain a National Safe Transit Testing Laboratory in each of our plants. It is of as much benefit to ourselves as it is a service for customers. Not only can we duplicate the program which has been described, but there is other equipment for scientifically predetermining the goodness of a package or the quality or the construction of an item. We can tell from vibrating whether a finish will become marred or abraded by the protective padding material. We can detect whether joints are substantial enough. We can decide if glass will become scratched. From Conburring and dropping, we can determine how well the product will withstand riding and handling—how it absorbs the shocks which it might have to take.

Testing Corrugated Board

Then there is the Mullen Test which is the standard gauge for all corrugated board. The Mullen Tester is an instrument which measures and records the bursting or pop test—or the puncture resistance of the board.

A piece of board is clamped in the machine. Under the board is a flat rubber diaphragm. When pressure is built up in the chamber underneath the diaphragm, it bulbs up gradually against the board, and finally breaks through. A reading is given on a dial at the high point reached before complete puncture. This is a fine test for a single sheet of paper, but many times on combined board a higher test is recorded on poorly fabricated, soft board than on well adhered, rigid board.

As a check-mate, we make use of the Beach Puncture Tester. This machine consists of a metal arm on the end of which is a three-sided point to resemble a sharp corner. After the board is clamped in position, the metal arm is released from its starting point, swinging in an arc. The sharp point contacts the board and penetrates it. Again, a recording is registered, indicating the high point of resistance to penetrating.

This test is one of motion and force which is more realistic than where just constant pressure is applied. There are not many instances when damage would be done simply by one article pressing against another. But, visualize what would happen when a plow point is laid or dropped on a box—or the sharp corner of one box is rammed into the side of another.

The compression testing machine is the best control of quality. Compression strength or stacking strength may not be the most important thing in a furniture box, as it is in numerous cases for packaged products. Nevertheless, having a standard and maintaining it gives a lever on manufacturing.

Regularly, representative boxes from production runs are checked. An empty box is set up and sealed. It is placed under a metal plate on which rests a weight. Additional weight is added gradually until the box collapses. The total weight divided by the perimeter of the box gives the pounds per perimeter inch of resistance to collapse.

If failure or substandard results are obtained, it's time to cut into the board and find out why. Poor adhesion, high and low corrugations, leaning corrugations, flutings mashed by printing—all or any one of these make an inferior box.

Conclusion

The corrugated box industry should take as much credit as possible for the splendid results of the fibreboard packages, without taking due commendations away from any other group. Naturally, this industry is a little selfish in that we want to make a market for our product, but we feel that we have something to offer. The results speak for themselves—more protection, safer delivery, lighter weight, more economy. These are the tangible dividends for faith in an idea and an industry.

Serving furniture accounts requires suppliers with thorough knowledge of their products and all requirements pertaining to packaging and transportation. To be a box salesman, one should possess almost engineering skill. Recently it was said that the purchasing agent of a large national concern had kept a record for a couple of years and made the statement that at least 75 per cent of the salesmen calling on him did not know what they were doing. A good salesman is a consultant to the buyer. The packaging of furniture is not a job for an order taker.

This has been an outline of a rather detailed approach to only one phase of packing. This is as necessary as keeping supervision on every operation. There is no substitute for quality and quality cannot be inspected into any product. This industry will continue with the aim of making a product even better for safe delivery of the products made by its customers.

Around the World in Forest Products Research and Development

Impressions of the Hannover Industrial Fair

M. L. SELBO[1]

GERMAN INDUSTRY on the march was potently exhibited at the Hannover Industrial Fair held at Hannover, Germany, April 29 to May 8. The West German Republic now stands as the largest exporter of woodworking machinery, with U. S. A., England, and Sweden following in that order. This export, of which Europe takes about 70 per cent and the United States about 10 per cent, has increased 94 per cent in four years.

Although the production of the woodworking equipment industry only amounts to 1.6 per cent of the total production and 2.1 per cent of the export of machinery in West Germany, the woodworking equipment industry was well represented at this fair, with more than 170 exhibitors out of a total of 3946. (There were exhibitors from 18 countries and 414 of the exhibitors were from outside of West Germany.)

The attendance totaled about 1.2 million, with representatives from 82 different countries. The power consumption at the fair was reported to be equivalent to that of a city with more than 100,000 inhabitants. This enabled the exhibitors to run their equipment as under normal operation.

A beltsander in which the entire length of a panel is sanded in one pass by merely feeding it at right angles to the direction of rotation of the sanding belt was reported to be a rather recent development (Fig. 1). A tenoning machine that can be used

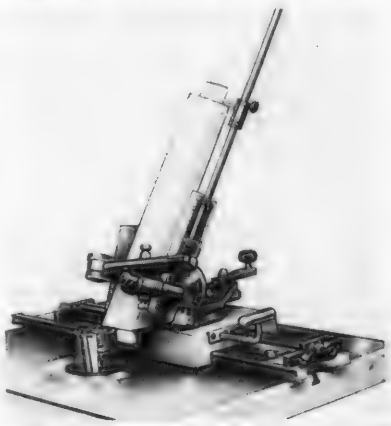


Fig. 2.—Tenoning machine used with shaper to produce tenons of practically any shape and form.

in combination with a common shaper was reported to produce tenons of practically any shape and form in a single operation (Fig. 2). A double-end tenoner made by another firm was said to represent the latest in this type of machine.

A great deal of pneumatic and hydraulic equipment for assembling and other purposes was shown. A new pneumatic fixing device which is marketed under the name of "Vacuum Fixer" (Fig. 3) is finding considerable use in the furniture plants of European countries. It employs suction cups or discs for holding an item in a fixed position while certain operations are performed on it, and has the advantage of affording instantaneous fixing or release as well as permitting the item to be held in practically any position.

Scraping instead of sanding or in combination with sanding is practiced to some extent in Europe and a machine for automatic sharpening of scraper blades was shown. Other items of interest were drum sanders equipped with thicknessing attachment for sanding to exact thickness and table jointers equipped with a vertical cutter for squaring one edge of the pieces in the same operation as they are jointed.

Of interest to research workers in various fields might be a microscope with built-in camera for taking photomicrographs at various magnifications.

[1] Mr. Selbo, during the academic year 1955–56, was a Fulbright research scholar at the Norwegian Institute of Woodworking and Wood Technology, Oslo, Norway. During this time he was on leave of absence from the U. S. Forest Products Laboratory, where he is head of the Section of Glued Laminated Products.

President-Elect Kaufert Reports Korean Observations

Dr. F. H. Kaufert, Director of the Minnesota School of Forestry and FPRS President-Elect, is on a three-month assignment in Korea advising on the rehabilitaiton of the forestry program of Seoul National University.

He writes: "This is an amazing land. In Korea things must be done by hand if they are to be done. They have plenty of hands—24 million people in a land half the size of Minnesota.

"About 90 per cent of the forests are used for fuel. Sawlogs and sawmills are scarce but present. I visited a sawmill where all of the logs were packed in on A-frames or back packs by men and bulls. The average log was 6 feet long and 5 inches in diameter, very few were larger. The majority of the so-called forests are cut clear annually with hand sickles. This brush and grass, little of it more than 4 feet high, is used for fuel. The leaves and needles are then raked up and used for compost or fuel. The result is devastation at its worst—millions of acres of almost bare mountains that have been eroded severely after hundreds of years of misuse."

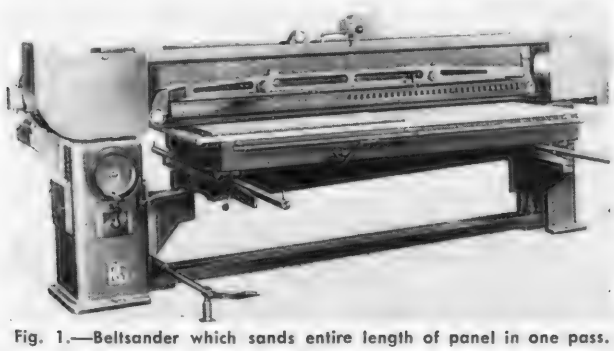


Fig. 1.—Beltsander which sands entire length of panel in one pass.

Fig. 3.—Pneumatic fixing device is used for holding item in position while certain operations are performed.

Abstracts From Current World Literature

Seasoning

Stevens, W. C. and Pratt, G. H. The effects of air movement in kiln drying. *Timber Technology*, Vol. 63 No. 2190, April 1955, p. 179

This article deals with the effects of increasing the air speed and reversing the direction of flow in kilns. The conclusion drawn from the very exhaustive tests is that by increasing air speeds and reversing the direction of circulation, the length of the inevitable time lag in drying across a pile of timber may be reduced. The size of this reduction depends on condition of the timber being dried. It will be large with a green wood and small with a partly seasoned wood. Detailed drying schedules for use with high air-speed quick reversing kilns have not yet been evolved. [F.D.C. Tech. Bul. V. 5, No. 29]

Economics

Zivnuska, J. A. Supply, demand and the lumber market [in the U.S.A.] *J. For.* 53 (8), 1955 (547–53).

Assumptions that emphasize demand aspects, e.g. the rising *per caput* consumption of metals and plastics at the expense of wood [cf. *For. Abstr.* 16 (Nos. 2093–4)] are criticized, and a working hypothesis of supply-and-demand trends is developed on the basis of data from 1921 to 1953. The concepts of price theory (illustrated in a diagram) and 'elasticity' in supply and demand are introduced to clarify the analysis, which reviews the trend of U.S. production and prices (in constant dollars) for 1921–53 and gives regression lines and equations for price and quantity for the periods 1921–29, 1931–41, 1947–53. Regional production is discussed and the conclusion reached that the lumber demand, while subject to great cyclical shifts, has a general upward trend, with its highest level in the recent post-war period. This expanding demand is probably becoming more elastic. The lumber supply, also fluctuating cyclically, shows an inelastic response to price in expansion at high levels and a more elastic response in contraction. The general trend is downward, the post-war period showing the highest level of costs. This declining supply is probably becoming more inelastic. An important reason for the decline is the shift from old to new-growth timber but improvements in the application of labor, in logging and milling efficiency and in organization, rather than increases in standing timber, are the more immediately available controlling factors. Improved forest management, e.g. in the present very rapid development of private forestry, will limit supply, making it less elastic. For the individual producer, however, only a rising demand can hold prices above his rising costs. The rising demand of the recent tremendous economic expansion has increased the demand for alternative materials. A better product at a lower price may also be important in protecting and expanding the lumber market. [For. Abs. V. 17, No. 1]

Chemical Barking

Tuovinen, A. Studies on chemical barking. *Paperi ja Puu* 37, no. 12: 575–88, 590–1, 593–7 (Dec., 1955). [In Finnish; English summary]

The results of an extensive Finnish co-operative study on the chemical barking of spruce, pine, and birch are presented, with particular reference to possible labor savings in manual and mechanical barking carried out under the usual operating conditions of the country. A 40% sodium arsenite solution was applied in all cases during June, July, or August. The weight of treated stems was essentially the same as that of the untreated logs in the case of spruce and birch; pines dry up to a certain extent after treatment. Conifers killed with sodium arsenite do not become resinous, so that arsenic-treated spruce and pine timber becomes more waterlogged during floating than untreated timber; this was particularly noticeable with small pine logs. [Bul. Pap. Chem. V. 26, No. 7]

Waste Utilization

Lunt, H. A. The use of woodchips and other wood fargments as soil amendments. *Bull. Conn. Agric. Exp. Sta.* No. 593, 1955. pp. 46.

Studies were made over a 5-year period to determine the effect of Oak, Hickory, Aspen, Grey Birch and Red and White Pine, alone and in mixtures, for soil improvement, in greenhouse pots and outdoor frames and on field plots. The material was usually applied once and worked into the soil, with or without extra N. Results show that: (1) The material had no appreciable effect on soil acidity and was not toxic to plants, apart from causing temporary N deficiency. (2) It had a small, generally favourable effect on soil structure, organic-matter content and associated soil properties. (3) Fresh chips almost invariably reduced growth of the first crop and were not consistent in their effect on succeeding crops, but when supplemented with enough N or composted, they did not diminish first crop yields and generally increased subsequent yields. (4) Chips are probably more effective on sandy soils than on loams, although very coarse-textured soils may become excessively loose and open at first unless the chips are composted. (5) Birch chips decomposed more rapidly than either Oak or Pine and would require the most extra N, while Pine decomposed slowly and would require the least. Pine chips were generally more effective than Oak or Birch in improving the soil. [For. Abs. V. 17, N. 1]

Properties

Armstrong, F. H. The strength properties of timber: The 2-in standard for tests of small clear specimens. *Forest Products Research Bulletin* No. 34, 1955.

Material for routine tests has recently been obtained from trees of small dimension, and for testing these species a specimen of 2 cm square cross-section has been used instead of one of 2 in square cross-section. The routine tests made on the 2 cm specimens have provided supplementary data on some of the species previously tested in the 2 in size. They have also given information on the strength properties of additional species of hardwood and some softwoods, some of which have been introduced only recently into the home market.

Figures for the strength properties of about 40 species of timber are included in the appendix. [F.D.C. Tech. Bul. V. 5, No. 30]

Brock, G. R. The strength of nailed joints: parts 1–2. *Timber Technology*, Vol. 63 Nos. 2194–5, August–September 1955, pp. 409–411, 466–469.

Extensive tests were carried out to discover the relationship between the shear strength of a nailed joint, the specific gravity of the timber and the size of nail used. The test specimens consisted of two or three pieces of timber overlapping longitudinally and joined by a nail through the overlap. These specimens were tested by placing them in a compression machine, the compression acting along their length. The size of load to cause a given slip was measured.

It was found that for a given nail size the stiffness and strength of the joints were directly proportional to the specific gravity of the timber used (European redwood); that the stiffness and strength of the joints at a given specific gravity were directly proportional to a power of the diameter of the nail; and that the load to cause a given amount of slip can be obtained from the equation $P = kGd^n$ where P is the load in pounds, G is the specific gravity of the wood, d is the nail diameter and k and n are constants. [F.D.C. Tech. Bul. V. 5, N. 29]

The preparation of abstracts from world literature in many languages is so highly specialized and costly that the Forest Products Research Society has no abstracting service of its own. For the abstracts in this issue of the JOURNAL the Society is indebted to the respective abstract journals indicated, from which they have been selected with the kind permission of the editors. Readers wishing information in addition to that given in these abstracts should consult the original articles referred to. Copies or additional information can not be supplied by FPRS or the abstract journal. The journals from which abstracts are published in this issue are as follows:

BULLETIN OF THE INSTITUTE OF PAPER CHEMISTRY, published monthly at Appleton, Wisconsin by the Institute of Paper Chemistry, subscription price $25 per year. This Bulletin publishes over 3,600 abstracts per year on subjects of interest to manufacturers of pulp, paper, fiberboard and allied products.

CHEMICAL ABSTRACTS, published semimonthly by the American Chemical Society, Executive Office—1155 Sixteenth Street, NW, Washington 6, D. C., subscription price $60 per year plus postage. This abstract journal publishes many thousands of abstracts annually with broad coverage of world literature in the entire field of chemistry and allied subjects.

FORESTRY ABSTRACTS, published quarterly by Commonwealth Agricultural Bureaux, Farnham Royal, Slough, England, subscription price $8.40 per year. The abstracts are prepared by the Commonwealth Forestry Bureau, Oxford, England, and include a Forest Products and Utilization section. This section contains over 1,500 titles and abstracts per year from literature in some 30 languages, covers all aspects of forest utilization.

TECHNICAL BULLETIN OF THE FURNITURE DEVELOPMENT COUNCIL is published bimonthly by the Council at 11 Adelphi Terrace, London W. C. 2, England. The Technical Bulletin publishes hundreds of abstracts and reviews from world literature annually, relating to the various phases of the furniture manufacturing industry. Subscription price is $5 per year.

Review of FPRS Section Meeting Papers

Practical Application of Cutting Speeds

C. L. Babcock, President, Babcock Machinery Co., New York. FPRS Northeast Section Meeting, Nov 4–5, 1954, New York City.

All woodworking plants face the problem of selecting proper planing equipment and especially head equipment running at the most advantageous speed. In the following discussion, the cutting action referred to is that of a 4-sided planer or moulder, not over 15 inches wide.

The quality of planing is determined by the number of visible knife marks per inch, which varies according to the kind and condition of the lumber. The goal to be attained is the greatest number of visible knife marks per minute. To obtain this goal, it is necessary to study the problem from all angles and the answer depends largely on the length of the runs.

The greatest number of knife marks per minute can be obtained by using a round head with high speed steel knives. From 4 to 16 knives can be used in the head running at 3600 rpm.

It is possible to joint knives effectively, with as many visible knife marks as there are knife cuts, only at speeds of less than 4000 rpm. At higher speeds, even though every knife cuts, there is only one knife mark per revolution.

At speeds higher than 4000 rpm, the number of knife marks per minute can be built up by increasing the revolutions per minute of the head in a ball bearing planer. When running faster than 3600 rpm, centrifugal strain causes unbalance at a much greater ratio than the rpm. At such speeds, heads should be dynamically balanced.

At high cutterhead speeds, it is sometimes necessary to use carbide-tipped knives. The latter do not seem to do good smooth work at 3600 rpm on nearly all species of wood. Fuzzy grain and raised grain is more common with carbide knives and they cannot be effectively jointed. At head speeds of 10,000 to 12,000 rpm or more, their use has proven satisfactory on moulders, routers, or shapers.

High speeds can be dangerous if not properly handled. Difficulties usually encountered are caused principally by the type of cutterhead bolts used, tightening of them, careless balancing, using short knives, improper set ups, and shavings lodging between knives and lips of battered heads, causing knife breakage.

The Human Element in Technological Change

W. L. Rabenstein, Management Development Director, Kroehler Manufacturing Co., Xenia, Ohio. FPRS Great Lakes Section Meeting, Dec. 2, 1954, Grand Rapids, Mich.

Why do employees develop resistance to the introduction of new equipment, machinery, and methods, and what can be done about this resistance? Unfortunately, the problem is too complex to lend itself to any sure-fire formula. Where you are dealing with a situation that involves attitudes, feelings, prejudices, beliefs, and ideas of people, you must always in some measure "play by ear". However, some specific recommendations can be helpful in gaining employees' cooperation.

By introducing technological changes, we at times deny employees some of the things they want from their jobs. We are frustrating them in their efforts to satisfy basic needs. What are some of these basic needs?

People want dignity.[1] They want to be respected and treated as something more than productive and non-productive labor. They want the certainty that they are useful and important to the organization.

People want togetherness. They need membership on a work team. We live, move, and have our being in a social environment that stimulates us to attach our loyalties to groups with whom we associate.

People need security. The majority of people want to be independent and self-reliant. In many cases, the employee's security is his job. Anything that he feels jeopardizes his job in any way, he sees as a threat to his security.

1. Keep morale at a high pitch at all times, thus building a sound bridge of trust, confidence, and respect between employees and management.

2. Do not assume that employees are going to resist a change just because it is a change. This will blind you to the real cause of their resistance.

3. Evaluate the actual and possible effects of the new method.

4. Consider employee beliefs that would interfere with acceptance of change.

5. Plan any changes far enough in advance and, if possible, transfer eliminated employees.

6. Thoroughly brief foreman or first line supervisor on the change and its advantages.

7. If staff people are to introduce the change, be sure they are well prepared and will not upset relationships in the plant.

8. Carefully examine the possibility of having the employees participate in the development of a new method or in the introduction of new machinery.

Giving some thought to what employees think is not only the most considerate thing to do, in most cases it is also the most profitable.

[1] This analysis of needs is taken from an article by P. D. Arnold, "Human Relations in a Hard-Sell Period," American Management Assoc. Mfg. Series No. 214.

Considerations That Must Be Given to Wood for Farm Structures

D. G. Carter, Professor of Farm Structures, U. of Illinois, Champaign, Ill. FPRS Midwest Section Meeting, April 11–12, 1955, Champaign, Ill.

Farm structures are important to the lumber industry for the producers, fabricators, and distributors have a $1 billion a year stake in farm service buildings, as well as another $1 billion annually for farm dwellings.

Some segments of the lumber industry have given a great deal of attention to the farm market. Their research, development, and promotion programs have been partly responsible for the many farm uses found for plywood, laminated arches, creosoted products, and pre-assembled trusses.

However, the lumber industry in general has not faced up to far-reaching changes that influence what the farmer wants and needs in the way of buildings.

Within the past few years, farm structures have changed in character. In contrast to the traditional barns, corn cribs, poultry houses, machine sheds, and other structures, the new demand is for ground level storage, separate and sometimes movable storage bins, and utility-type buildings that are post-free, large, lightweight, low cost, and open plan.

At the same time, the manufacturers of products competitive with wood moved in on the farm market. They brought the welded steel frame, the tight bolted truss, metal coverings, combinations of steel, aluminum, asbestos, and asphalt.

A striking opportunity is waiting for lumber interests to embark on a program to take back a good deal of the market for manufactured buildings, building units, panels, trusses, and package jobs. Such action depends on willingness to conduct research on a fairly extensive scale, preferably in cooperation with institutions that have close association with agricultural research.

Timber Engineering Company

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The only Commercial Laboratory in the United States and Canada offering the services of a modern, fully equipped, and highly versatile Pilot Plant for the development of platen-type wood particle boards.

Facilities for testing and evaluating all types of wood particle boards and their raw materials, manufacturing processes, end uses, and markets.

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Tenth National Meeting Largest in FPRS History

(Continued from page 41-A)

Kirk & Blum Manufacturing Co., Cincinnati, Ohio
Koppers Co., Inc., Pittsburgh, Pa.
Eli Lilly Co., High Point, N. C.
Masonite Corp., Chicago, Ill.
Miller–Hofft, Inc., Richmond, Va.
National Casein of N. J., Riverton, N. J.
Nelsonite Chemical Products, Inc., Grand Rapids, Mich.
Norment & Lambert, Inc., Lenoir, N. C.
Pacific Lumber Co., Chicago, Ill.
Perkins Glue Co., Lansdale, Pa.
Protection Products Manufacturing Co., Kalamazoo, Mich.
Raybond Electronics, Inc., Newton-Highlands, Mass.
Rockwell Manufacturing Co., Pittsburgh, Pa.
Simonds Saw & Steel Co., Fitchburg, Mass.
S. H. Smith Co., Publishers, Indianapolis, Ind.
Soderhamn Machine Manufacturing Co., Talladega, Ala.
Solem Machine Co., Lockport, N. Y.
Southern Screw Co., Statesville, N. C.
Standard Dry Kiln Co., Indianapolis, Ind.
Synvar Corp., Wilmington, Del.
Timber Engineering Co., Washington, D. C.
U. S. Plywood Corp., New York
Wilco Machine Works, Memphis, Tenn.

EXHIBITS AND DOOR PRIZES attracted attention of ladies attending meeting. Looking over saw at left are Mrs. A. Midyette, Mrs. E. S. Johnson, and Mrs. W. R. Smith. Door prizes at right are viewed by Mrs. O. B. Smith, Jr., Mrs. B. Granum, Mrs. R. H. Berry, and Mrs. R. H. Bescher.

Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.
Yates–American Machine Co., Beloit, Wis.
Redman Engineering Service, High Point, N. C.

Section Officers Advisory Committee Luncheon

Thursday noon, June 7, the National Executive Board met at a luncheon with some 36 representatives of FPRS' 13 sections in the Rhododendron Room of the Battery Park Hotel to discuss Society business of mutual interest. A complete report of this meeting is on page 73–A of this issue.

Traditional "FPRS Party"

The final evening of the meeting was devoted to the annual FPRS banquet and party, attended by some 500 men and ladies in the city auditorium. Entertainment was provided by the "Song and Dance Champions of the 8th Annual Mountain Youth Jamboree," and consisted of authentic mountain songs and dances found in the Smoky Mountain region. Performers were local youths found by screening talent from 60 schools in the area.

Galaxy of Door Prizes

Nine door prizes were presented during the banquet, and other prizes, all donated by local furniture companies and other manufacturing concerns, were distributed throughout the week. A list of these prizes and the winners is shown below.

DOOR PRIZE	*DONOR*	*WHERE DRAWN*	*RECIPIENT*
Vanity Stool	Hibriten Chair Co.	Monday—Exhibit Hall	Mark M. Lehrbas
Chair	Century Furniture Co.	Tuesday— " "	Selwyn H. Fox
Bed	Empire Furniture Co.	Wednesday— " "	Mrs. R. E. Norment, Jr.
Fire Pump	D. B. Smith Co.	Thursday— " "	George Garratt
Lazy Susan	Unique Furniture Co.	Monday—Ladies Tea	Mrs. J. F. Haskins
Table	Lexington Chair Co.	Monday— " "	Mrs. Noel E. Kittell
Coke Picnic Box	Cavalier Corporation	Monday—Children's Party	Janie Goldstein
Chair-Desk	Brunswick–Balke–Collender	Tuesday—Children's Movie	Barbara Keppler
Lamp	Erwin Lambert Co.	Tuesday—Official Luncheon	Lee Moffett
Table	Hammary Furniture Co.	Tuesday— " "	William G. Graeter
Chair	Globe Parlor Furniture Co.	Thursday—Banquet	George Phillips
Coffee Table	The Lane Co.	" "	W. H. Reid
Table	Heritage Furniture Co.	" "	Clark C. Heritage
End Tables	Gravelly Nov. Furniture Co.	" "	Mrs. William Masengill
Table	Walnut Wood Carving Co.	" "	Mrs. T. R. Mikels
Chair	Broyhill Furniture Co.	" "	J. B. Doughty
Mirror	Fox Manufacturing Co.	" "	Mrs. H. J. Bluhm
Table	Brady Furniture Co.	" "	R. Halpen
Table	Drexel Furniture Co.	" "	Mrs. L. F. Bornstein

TOAST TO ALMA MATER was proposed by E. P. Ivory (seated fourth from left) at reunion luncheon of alumni of New York College of Forestry Syracuse.

300 Attend Plant Tours

Friday, June 8, was devoted to plant tours to ten wood using industries in the Western Carolinas. A total of some 300 persons visited these plants. The official pre-registration for plant tours was as follows:

Plant	*Pre-registered*
Broyhill Furniture Factories, Lenoir, N. C.	31
Drexel Furniture Factories, Drexel, N. C.	14
Taylor–Colquitt Co., Spartanburg, S. C.	0
Poinsett Lumber & Mfg. Co., Pickens, S. C.	35
Williams-Brownell, Inc., Asheville, N. C.	7
Draper Corp., Swannanoa, N. C.	2
Champion Paper & Fibre Co., Canton, N. C.	11
Morgan Mfg. Co., Inc., Black Mt., N. C.	24
Ecusta Paper Corp., Pisgah Forest, N. C.	8
American Enka Corp., Enka, N. C.	5

Outstanding Ladies Program

The ladies' and children's program, under the able direction of Mrs. Walton Smith and her committee, was the most varied in the Society's history. It began with a get-acquainted hour in the George Vanderbilt Hotel on Monday morning. Monday afternoon a tea was held at the Grove Park Inn with the children being provided with a separate supervised party at the Inn.

REUNION BREAKFAST was held by Penn State alumni.

PLANT TOURS were made to ten western Carolinas industries. Left, registrants view combination bolter-trim saw at Draper Corp. Right, inspecting hardwood flooring and paneling in new offices of Williams–Brownell, Inc.

HOST COMMITTEE for Tenth National Meeting included, front row: J. S. Bethel, Exhibits; Mrs. W. R. Smith, Ladies Program; G. M. Hill, Finances; W. L. Irwin, Entertainment; back row: E. S. Harrar, General Chairman; H. J. Loughead, Publicity; J. B. Hayward, Paul Bunyan Barbecue; Walton R. Smith, Asheville Arrangements.

Tuesday afternoon the ladies visited the world-famous Biltmore House & Gardens, former home of the late George Vanderbilt. A leading cultural attraction, it is regarded as the showplace of the South and contains priceless paintings, tapestries, and antiques from all over the world.

Throughout the week various entertainment was provided for children of all ages, including movie parties and teen-age get-togethers.

On Wednesday and Thursday regular social events of the Paul Bunyan barbecue and the annual party provided the remainder of the social activities for the ladies.

Splendid Teamwork Responsible for Meeting Success

Credit for the success of FPRS Tenth National Meeting is due in large measure to the volunteer committee members who spent many hours in preparation for and during the meeting to assure a smooth-running event.

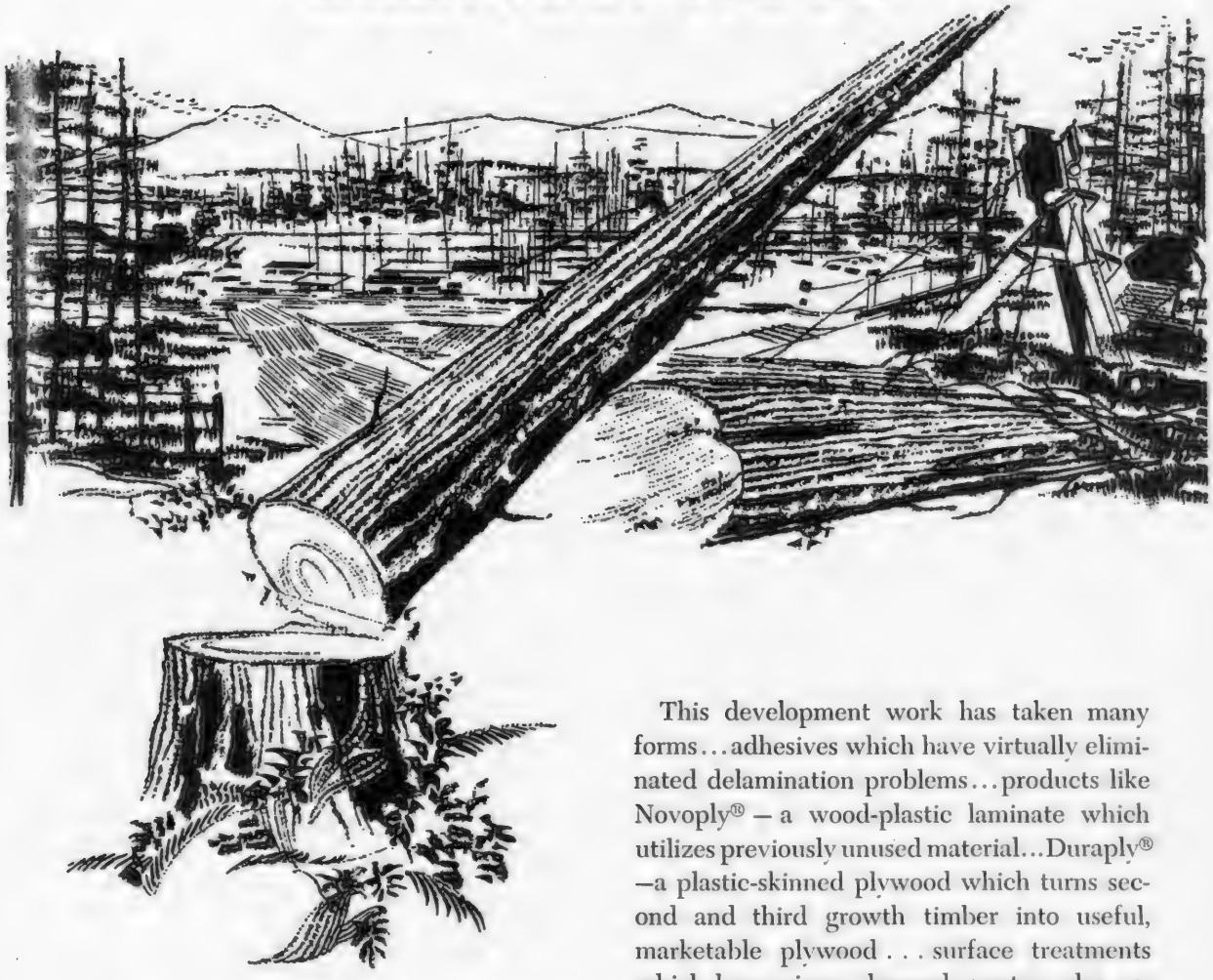
General Chairman E. S. Harrar was responsible for co-ordinating the work of the entire committee, which demonstrated splendid teamwork throughout the week. Walton R. Smith, Asheville Arrangements Chairman, did an outstanding job in overseeing details on the scene, and was assisted by several staff members of the Southeastern Forest Experiment Station.

James S. Bethel was in charge of arrangements for the highly successful "Suppliers Exhibit". Assisting his committee during the week were six students from N. C. State College. Jack Hayward was Chairman of the Paul Bunyan Barbecue, social highlight of the meeting.

Local publicity, under the chairmanship of Harvey Loughead, was the most complete in FPRS history. In addition to daily newspaper coverage, four television programs were arranged and viewed by a six-state audience. Details of finance and budget were ably handled by G. M. Hill.

Other committee members contributing to the meeting were: finance, C. M. Carey, Jr.; publicity, R. L. Buchholz and W. J. Damtoft; Paul Bunyan Barbecue, J. Colucci, Jr., R. C. Garrison, and R. G. Lenox; exhibits, H. A. Lockemer, R. E. Palmer, and P. F. DeSaix; meeting rooms, signs, and supplies, A. S. Todd, Jr.; transportation and field trips, B. M. Winerow; housing, M. A. Taras; registration and tickets, J. B. Veach, Jr. and A. C. Barefoot; entertainment and meals, W. L. Irwin and R. A. Wood; hospitality, J. B. Veach, Sr.; door prizes, R. M. Carter and E. S. Johnson; and ladies program, Mrs. W. R. Smith.

There's more in a log than just wood



To the United States Plywood Corporation a log is not just a quantity of wood to be processed and sold. Rather it is our means for creating new products for the American people and new markets for the entire wood industry.

For almost 40 years we have engaged in research that has developed just such products. It has also resulted in a more efficient utilization of our timber resources.

This development work has taken many forms... adhesives which have virtually eliminated delamination problems... products like Novoply® – a wood-plastic laminate which utilizes previously unused material... Duraply® –a plastic-skinned plywood which turns second and third growth timber into useful, marketable plywood . . . surface treatments which have given plywood greater sales appeal, in products such as Weldtex® and Surfwood®... and finishing methods which have widened fir plywood markets and have started the trend to prefinished hardwoods. These are but a few examples of research which has contributed to the health and growth of our industry and company.

To us a log will always be an opportunity to enhance our nation's economy... our industry's growth... and our people's way of life.

United States Plywood Corporation Weldwood

Weldwood—The Best Known Name in Plywood

LOVSTED'S DRY KILNS ARE THE MOST EFFICIENT IN OPERATION TODAY

LOVSTED'S DIRECT-FLO DRY KILNS

Whatever the specific problem of lumber seasoning, there's a solution in some type of Lovsted "Direct Flo" Kiln. These units, without question, are the most efficient kilns in operation today. They embody such specialized features as reversible circulation with fans positioned to create uniform drying with lowest possible power input per cubic foot of air produced. Look to the engineers of C. M. Lovsted and Co., Inc. to bring your own lumber seasoning to efficient operation.

★ *PROFITS AHEAD WITH LOVSTED!*

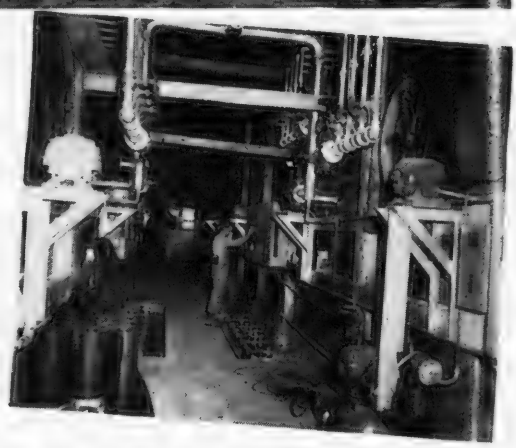
TOOTS-E SIGNALS

TOOTS-E TYPE "D"

TOOTS-E TYPE "J"

TOOTS-E JUNIOR

SPECIAL SIGNAL SERVICE FOR 35 YEARS



FOR FOREST AND FACTORY . . .

Serving the signal needs of forest and factory for over thirty-five years, C. M. LOVSTED engineers have developed a full line of Air, Steam, Electric and Vacuum Signal Systems. Their extreme dependability and long life are the result of high standards rigidly maintained. Write today to our Dept. FP-10, outlining your signal problem and we will give you complete technical information that will help you in its solution.

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c/o Smith Bell & Co., Ltd.
123 Juan Luna St., P. O. Box 311
MANILA, R. P.

Minutes of FPRS Tenth Annual Business Meeting

(Continued from page 49-A)

Be it resolved that the appreciation of the Society be extended to the management and the staff.

5. Recognizing the contributions that the over 50 Paul Bunyan Barbecue Sponsors have made to the social portion of our meeting,

Be it resolved that the Society extend its appreciation to the Sponsoring Companies and Organizations.

6. Recognizing the contribution that the 70 table-top exhibitors have made to the success of the meeting,

Be it resolved that the Society extend its appreciation to the Sponsoring Companies and Organizations.

9. Report of Tellers Committee

Your Tellers Committee, composed of George A. Garratt, Edward G. Locke, Herbert O. Fleischer, W. L. Lear, Fred E. Dickinson, Ben S. Bryant, William H. Reid, and the Chairman, have counted the ballots and report the following elected: President-Elect, Frank H. Kaufert; Vice-President, W. J. Eason; Southeast Regional Board Member, William L. Irwin; South–Central Regional Board Member, W. R. Warner; 1957 National Nominating Committee: Fred E. Dickinson, George A. Garratt, Edward G. Locke, Clark C. Heritage.

Submitted by James F. Hamilton, Chairman. Upon motion duly made and seconded, the report was accepted.

10. Introduction of New Officers

Retiring President Moss B. Christian, having served for six consecutive years on the Executive Board, acknowledged and extended the gratitude of the Board to these outgoing Board Members: Past President L. J. Carr, who served seven years; E. S. Harrar, Duke University, Durham, N. C., who served three years; and Frank Parrish who served two years.

He introduced incoming members: Northeast Regional Board Member (1 year)—Charles R. Lockard; Southeast Regional Board Member (3 years)—W. L. Irwin; and South-Central Board Member (3 years)—W. R. Warner.

Mr. Christian then introduced the new President-elect Frank H. Kaufert, University of Minn., St. Paul; by proxy, the new Vice-President W. Jeter Eason, who was on an extended business trip to the Orient; and Christian's successor as President, Ralph H. Bescher, Koppers Co., Pittsburgh, Pa.

Mr. Bescher accepted the gavel of president, emphasizing the excellent all-around job which the previous administration had done—in governing, in membership growth, in outstanding papers at our meetings and finally, in an active Executive Board.

11. New Business

E. Chat Shanks, Babcock Machine Co., Baltimore, Md., on behalf of the city of Baltimore, extended an invitation to the Forest Products Research Society to hold its 1959 or 1960 National Meeting in Baltimore. He presented a brochure signed by the President of the Lumber Exchange, Chairman of the Baltimore Section ASME, Governor McKeldin of Maryland, and Mayor D'Allesandro. He was advised that the National Executive Board would review this and other invitations at a near-future meeting.

Ray Berry, Southwest Regional Board Member, extended in behalf of the Northern California Section an invitation to hold the 1959 National Meeting in San Francisco.

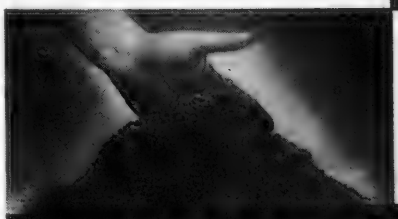
Joseph L. Stearns, Insular Lumber Co., Philadelphia, Pa., commented on what he felt to be a minor shortcoming of the present meeting. He stated that at future National Meetings the Society should have available each day or once during the meeting a mimeographed list of the registrants who are present, indicating their hotel room numbers. President Bescher advised that this subject would be considered for the next National Meeting.

12. Adjournment

President Ralph H. Bescher declared the meeting adjourned at NOON.

Get More From Wood Waste....

...MORE HEAT, more economy, if you burn it



...MORE PROFIT, lower costs, if you sell it

WILLIAMS "No-Nife" HOGS

When used for fuel, wood scrap reduced to chips in a Williams Hog produces maximum heat . . . burns evenly . . . won't restrict flow of air . . . keeps smoke at a minimum. Handling costs are reduced as much as 75%!

When processed for sale as particle board chips, or as sawdust or wood flour, a Williams Hog produces a better quality, more uniform product . . . increases output . . . requires less labor . . . keeps power and maintenance costs low.

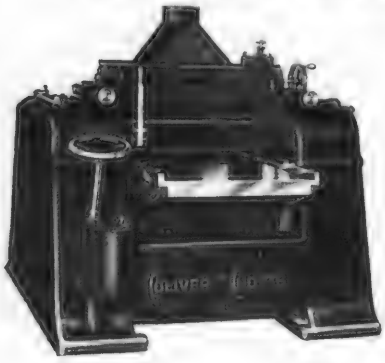
Automatic installations for handling wood waste show exceptional savings or profits.

Ask for brochure.

WILLIAMS PATENT CRUSHER & PULVERIZER CO.
2714 No. NINTH STR. • ST. LOUIS 6, MISSOURI

WILLIAMS
CRUSHERS GRINDERS SHREDDERS
OLDEST AND LARGEST MANUFACTURER OF HAMMER MILLS IN THE WORLD

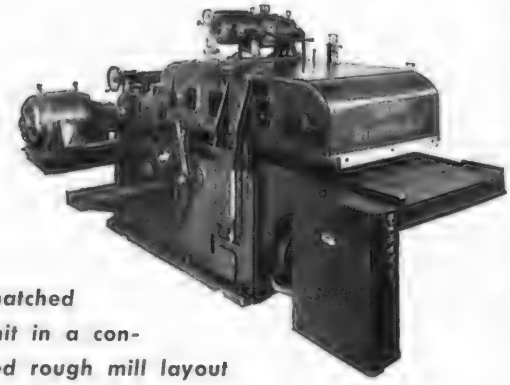
Low-cost production of smooth surfacing starts with an OLIVER



Plane it fast and smooth with No. 361 Surfacer

This Surfacer smoothly planes all woods up to 30 inches or 36 wide, up to 8 inches thick, at speeds up to 60 feet a minute. One-piece wedge type bed. Working parts kept in permanent alignment. Micrometer adjustment aligns bed and cylinder. Easy and convenient to operate. Write for Bulletin No. 361.

In one operation the Straitoplane takes stock out-of-wind . . . planes both sides smooth and parallel



It's unmatched as a unit in a conveyorized rough mill layout

In one pass the Straitoplane does the work of a facing planer and a single surfacer. It planes out as much as ¼" on each side at speeds up to 90' a minute. The bottom side is face jointed, and top side planed smooth and straight to desired thickness. The finished stock is perfectly flat, uniformly true. The Straitoplane takes stock any length, 1½" to 36" wide, ½" to 6" thick, short as 16" when fed singly. Many narrow strips can be surfaced at one time. The Straitoplane is used by leading woodworkers on high production work. Write for Bulletin No. 170.

There's an Oliver to save money on every operation

Vertical Borers	Jig Saws	Jointers
Horizontal Borers	Cut-Off Saws	Belt Sanders
Multiple Spindle Carvers	Saw Benches	Disk Sanders
Mortisers	Tenoner	4" Moulder
Band Saws	Shapers	Wood Trimmers
	Surfacers	Vises

OLIVER MACHINERY COMPANY

Established 1890 **GRAND RAPIDS 2, MICH.**

Cascades Plywood Corporation

Manufacturers of Douglas fir plywood and Lebanite (smooth-two-sides hardboard)

General office: Public Service Building, Portland, Oregon

Plants at: Lebanon, Oregon

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E. K. WOOD LUMBER CO.

RETAIL YARDS: Thermal · Van Nuys · Whittier · Long Beach
Sierra Madre · San Pedro

Suppliers Exhibit

(Continued from page 43-A)

National Casein Co., Riverton, N. J. —Adhesives

National Cylinder Gas Co., Chicago —Wood Preservatives

State University of New York College of Forestry, Syracuse—Education and Research

Norment & Lambert, Inc., Lenoir, N. C.—Machinery Representatives

North Carolina State College, Raleigh —Education and Research

Onsrud Machine Works and Onsrud Cutter Mfg. Co., Chicago—Woodworking Machinery and Cutterheads

Pennsylvania State University, University Park—Education and Research

Perkins Glue Co., Lansdale, Pa.—Adhesives

Power-line Sales, Inc., Detroit, Mich. —Stapling Machinery

Raybond Electronics, Inc., Newton-Highlands, Mass.—High Frequency Heating Machinery

Reichhold Chemicals, Inc., Charlotte, N. C.—Adhesives and Resins

Allen T. Shepherd Co., Armstrong Machine Works, Three Rivers, Mich.—Steam Traps

Simonds Saw & Steel Co., Middleburg, N. C.—Carbide Saws & Tools

S. H. Smith Co., Indianapolis, Ind.—Woodworker and Veneers and Plywood magazines

Southeastern Forest Experiment Station, Asheville, N. C.—Research

Spotnails, Inc., Evanston, Ill.—Nailing Machinery

Standard Dry Kiln Co., Indianapolis, Ind.—Dry Kilns

Steel Slides, Inc., Yonkers, N. Y.—Steel Furniture Slides

Timber Engineering Co., Washington, D. C.—Research Facilities

Tri-State Container Corp., Elizabethtown, Tenn.—Containers

United-Carr Fastener Corp., Cambridge, Mass.—Furniture Gliders.

U. S. Forest Products Laboratory, Madison, Wis.—Research

U. S. Plywood Corp., Charlotte, N. C. —Novoply and Plywood Products

R. T. Vanderbilt Co., Inc., New York City—Lumber Seasoning

Victory Carbide Saw & Tool Co., Chicago—Carbide Tools

Wel-Dri Co., Memphis, Tenn.—Dry Kilns

Weyerhaeuser Sales Co., St. Paul, Minn.—Hardboard & Chipcore

Wilco Machine Works, Memphis, Tenn.—Hot Presses and Woodworking Equipment

Williams-Brownell, Inc., Asheville, N. C.—Veneers

Williams Patent Crusher & Pulverizer Co., Inc., St. Louis, Mo.—Chippers

Woodwelding, Inc., Burbank, Calif.—High Frequency Heating Equipment

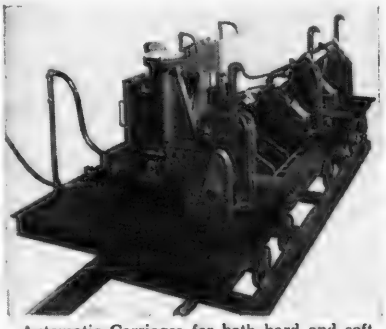
WE TAKE ORDERS FROM YOU

You've been giving us orders for seventy-eight years—telling us your needs and commanding us to find the answers.

We've got just one request to make—

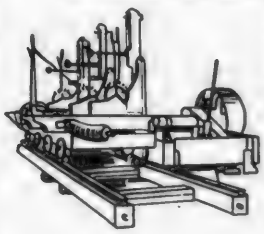
KEEP ON GIVING US YOUR ORDERS!

COMPLETELY ENGINEERED SAWMILLS AND SAWMILL COMPONENTS



Automatic Carriages for both hard and soft woods; completely air-operated; push-button control of knee taper, dogs, set works, flippers, etc.; accurate to .006 in. in normal cases; fast, flexible, rugged, labor-saving.

CARRIAGES AUTOMATIC OR HAND-SET

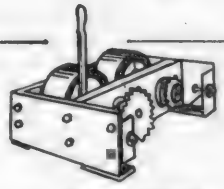


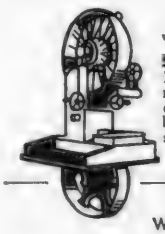
The industry's best values; in use all over the world for increasing operating profits, meeting exacting requirements. Fast-moving flexible, accurate, easily controlled, and *rugged*. For band or circular saws of all designs.

GIANT CARRIAGE FEEDS

ENTERPRISE DOUBLE TWIN-DISC CLUTCH TYPE

The finest clutch or friction feeds; faster cutting speeds with lower maintenance. For use with all ENTERPRISE sawmills, and with other models in the field. Wide variation of speeds, positive control, ease of operation. Automotive-type facings—long wearing and easily replaceable.



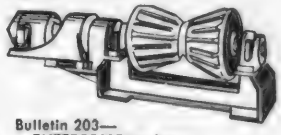


"Hoosier" BAND SAWMILL HEADRIGS

Heavy-duty; right or left hand models; for 10 in. or 12 in. saws; dynamically-balanced wheels; double-wall cast iron frames; standard sizes 54 in. and 6 ft.

LOG CONVEYORS

For use in wood rooms and log hauls, with cut-off saws, barkers, live decks, etc. Cast-steel roll with abrasion-resistant hardfaced teeth —makes slipping the roll impossible. Sizes 12 in., 18 in., 24 in. Twenty-four-inch roll face handles logs up to 36 in.-diameter.



WRITE FOR ***ENTERPRISE*** BULLETINS

Bulletin 201— **ENTERPRISE** Models 21, 34, and 56 Circular Sawmills, Headrigs and Carriages.

Bulletin 207— **ENTERPRISE** 54-in. and 6-ft. Band Saw Mills; Special Band Mill Carriages, Carriage Feeds.

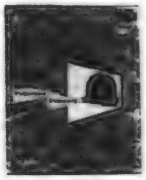
Bulletin 203— **ENTERPRISE** Top Saws, Lumber Transfers, Live Rolls Set Works, Headblocks, Special Drives, Log Roller Conveyor Units, Roll Cases, Complete Lumber Mills, Sawmill Supplies and Accessories.

ESTABLISHED 1870

It's ENTERPRISE that counts

The Enterprise Company • COLUMBIANA • OHIO

MURCO Wastewood Chippers



WRITE FOR NEW CHIPPER CATALOG

QUALITY - SPECIFICATION SIZE PULPWOOD CHIPS FROM • SLABS • EDGINGS • ROUND WOOD OR VENEER CORES —

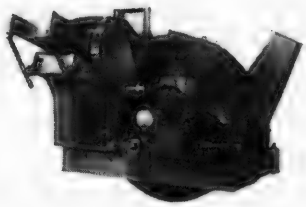
From the complete line of MURCO Wastewood Chippers here are illustrated three that are preferred by mills throughout the country who are producing quality specification-size pulpwood chips from sawmill waste, planer trimmings, slabs, edgings, round wood, veneer cores, etc. These mills have stopped burning dollars and are now selling chips. Their preference for MURCO Chippers is the MURCO outstanding performance producing more and better chips at less cost with less sawdust and slivers, free from repairs while at the same time having production records of one hundred cords or over per hour. It will pay you to investigate what MURCO Chippers can do for you.

D. J. MURRAY MANUFACTURING CO.

Manufacturers Since 1883 WAUSAU, WISCONSIN

MURCO — 48" — 6 knife Wastewood Chipper with 7" x 15" spout installed by Weyerhaeuser Timber Co.

MURCO — 12 knife — 64" Wastewood Chipper installed by Hallack & Howard Lumber Co. Winchester, Idaho.



MURCO — 75 Mechanical Feed Wastewood Chipper installed in Allison Lumber Co. Bellamy, Alabama.

Report of Section Officers—Executive Board Meeting

SECTION OFFICERS ADVISORY COMMITTEE met with National Executive Board to coordinate matters of mutual interest.

THE SEVENTH ANNUAL LUNCHEON MEETING of members of the National Executive Board and Section Officers and their delegates was held in the Rhododendron Room of the Battery Park Hotel, Asheville, on Thursday, June 7.

In general the meeting recommended a continued strengthening of liaison between the national executive office operations and those of the sections. It was recommended that copies of all correspondence to sections be sent to the chairman and secretary in addition to others concerned, to keep the officers currently informed on all matters affecting sections.

It was also recommended that a system be instituted for advising sections of the exact status of papers in the process of publication in the JOURNAL.

The meeting attendees commended the Industry–Education Committee for its foresight in planning literature intended for wide distribution to potential students in wood technology courses.

Those attending the meeting were: D. W. Bensend, Midwest; Ray H. Berry, Executive Board; R. H. Bescher, Executive Board; J. F. Burrell, Ohio Valley; L. J. Carr, Executive Board; M. B. Christian, Executive Board; William J. Delmhorst, Northeast; Fred E. Dickinson, Northern California; R. H. Elliott, Ohio Valley; N. C. Franz, Great Lakes; B. M. Granum, Upper Mississippi Valley; Jerome F. Habig, Ohio Valley; E. S. Harrar, Executive Board; R. L. Hiller, Executive Board; J. B. Huffman, Florida-Georgia–Alabama; W. L. Irwin, Executive Board; Paul Lane, Upper Mississippi Valley; C. R. Lockard, Executive Board; George G. Marra, Inland Empire; Earl T. McCarthy, Pacific Northwest; Rufus H. Page, Florida-Georgia–Alabama; Steve Preston, Great Lakes; John D. Ritchie, Executive Board; Edward Roche, Executive Office; Frank J. Rovsek, Executive Office; D. K. Saunders, Northeast; Carl Seng, Ohio Valley; Tom Shelton, Northern California; H. N. Stephenson, Northern California; J. R. Stillinger, Pacific Northwest; Tony Veazey, Inland Empire; W. R. Warner, Executive Board; John E. Wells, Mid-South; R. W. Wells, Mid-South; Frank H. Kaufert, Executive Board.

1. The minutes of the June 23, 1955 meeting were read. These called for establishment of a uniform section bookkeeping system, model section by-laws, revised membership application blank, scheduling of separate annual Section Officers meeting, and discussion of an institute of research. It was noted that the Executive Board had acted favorably upon all suggestions with the exception of the last, which is not within the immediate province of the Society.

2. President Christian then turned the meeting over to Chairman Tony Veazey of the Section Officers Advisory Committee.

Earl McCarthy, Northwest Section Membership Chairman, briefly discussed his experience in gaining new members. He emphasized continuity from year to year of a standing committee; naming of a sales representative as Section membership chairman; that Section meetings are the best source of new members; and finally, that non-members rarely attend more than two meetings before joining F.P.R.S.

3. The committee recommended that the Executive Office be careful to note that principal section officers be informed by copy of any correspondence affecting section activities. The Executive Board later moved to instruct the Executive Office to include section chairmen and secretaries in all correspondence relating to their section.

4. The committee endorsed the proposed brochure of the Industry–Education division as an important endeavor if the industry is going to attract students at the high school level into forest products curricula. The Executive Board subsequently advised that the committee has additional work to do in implementing the project. It was suggested that the American Forest Products Industries, Inc. might be a logical organization to undertake printing and distribution of this brochure. L. J. Carr was appointed chairman of a committee to serve as liaison between F.P.R.S. and N.L.M.A. in investigating a basis of putting this program into action.

5. The committee recommended that a method be implemented for reporting to sections on the status of papers submitted for publication. It was suggested that the Executive Office advise the sections on current status of papers on hand, acknowledge receipt of each new paper, advise sections of date being sent to reviewer, and send a follow-up postcard to the section after review.

It recommended that procedure for handling papers be included in the editorial style manual currently being prepared by the Executive Office.

The Executive Board approved these recommendations and instructed that they be instituted.

6. The committee recommended a review of the existing policy on preparation and issuance of preprints in conjunction with national meetings. The Executive Board voted that no change be made in the existing policy in view of the monthly FOREST PRODUCTS JOURNAL and an already heavy publishing schedule. A detailed explanation will be made to each Section.

Concluding the luncheon meeting, R. H. Berry, chairman of the constitution and by-laws committee, reviewed the proposed revision of section by-laws designed to create uniform by-laws among the 13 Sections consistent with those of the parent organization.

Mr. Berry, chairman of the executive office fund-raising program, outlined his plan of action to approach companies in the forest products industry for donations of $1,000 each toward a potential goal of $100,000. He asked the Section officers to assist in supplying names of top executives in organizations in their area who may be invited to participate.

The meeting was officially adjourned at 1:30 P.M.

No Warping, Checking or Splitting

...even in largest sheets with a

PROCTOR VENEER DRYER

Controlled Temperature

•

Improved Air Circulation

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Sturdy, Life-time Construction

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Wide Range of Types

Investigate the advantages of a

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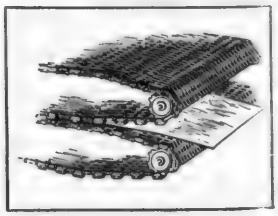
Dryer now . . . write or phone today for details.

Here is uniform, efficient drying at speeds that are consistent with highest quality. There is a Proctor Veneer Dryer to handle every type of cut, every type of veneer, every production requirement. Veneers dry evenly, without warping, to any desired moisture content.

WIRE AND GIRT CONVEYORS

Special Proctor-designed conveyors hold veneer in a fixed position during travel through the dryer, yet because of unique wire girt construction, the sheets can contract normally without warping, checking, or splitting. The open mesh of the conveyor exposes almost the entire surface area of the sheet for better drying.



PROCTOR & SCHWARTZ, Inc.

Manufacturers of Industrial Drying Equipment and Textile Machinery. Philadelphia 20, Pa.

1956 FPRS Subject Matter Division Reports

SHIRT-SLEEVE SESSION was held by Subject Matter Division Chairmen and President-Elect Frank H. Kaufert.

Plans Are Formulated For Coming Year

QUALITY CONTROL—June 4—Chairman, C. S. Latimer, Nickey Brothers, Inc., Memphis, Tenn.

The meeting was called to order at 2:00 P.M. Ben S. Bryant served as Secretary.

I. Plans for the 1957 National Meeting.

Dr. James S. Bethel made a motion, seconded by Ben S. Bryant, that the Quality Control Division have a technical session at the 1957 National Meeting. Lewis O. Reed suggested that papers should contain good case histories and adequate, but not complicated, details. Dr. Bethel suggested that a proper balance could be achieved by using technical papers as well as case histories. Dr. Bryant suggested a paper on a basic program for a particle board plant. Other specific paper possibilities were suggested. The motion was adopted.

II. Statistical Quality Control Brochure

Chairman Latimer brought up the subject of the statistical quality control brochure and reported on its progress—a modification of Mr. Tombach's series of articles. Willard Pratt's suggestion of a brochure made up of case histories (with $ sign attached) was favorably reported and was suggested for annual review. Dr. Bryant suggested combining the general treatment brochure, which is already in rough draft, and the case histories available within the group. R. C. Calahan, Singer Mfg. Co.; J. S. Bethel, N. C. State College; Aubrey Wylie, Michigan State University; Willard Pratt, California Redwood Association; and Charles Latimer, Nickey Brothers, volunteered to supply case histories.

III. Future Plans

Dr. Bethel shared a problem about Quality Control Short Courses concerning limiting personnel registered.

Copies of the tentative brochure were given to committee members for critcism after which they were to be sent to Chairman Latimer.

Dr. Aubrey Wylie presented copies of a paper entitled "Training for Quality Control Work." The consensus of the group was that he submit it as a contributed paper for the FOREST PRODUCTS JOURNAL since the group agreed that it was an adequate and timely piece of work.

The group briefly discussed new developments and potential developments in the field.

The meeting adjourned at 3:30 P.M.

VENEER AND PLYWOOD—June 4, 1956—Chairman, H. O. Fleischer, U. S. Forest Products Laboratory, Madison, Wis.

I. Annual Industry Report

Discussion of the annual industry report of the Veneer and Plywood Committee, published in the February issue of the Forest Products Journal, led to the conclusion that subsequent reports, at least for the next few years, should be restricted to activities in selected segments of the veneer and plywood field. Segments mentioned for treatment were: veneer; hardwood plywood; softwood plywood; and combination, modified, or "allied" veneer and plywood products. The last segment might include veneer and paper combinations, overlaid plywood, impregnated and treated plywood, plywood with surfaces modified by brushing or other mechanical treatment, veneer-particle board combinations, and the like. Tentatively it was thought that this last-mentioned segment might well be the subject of the 1956 report.

II. Report on Committee Functions

No progress has been made on the project, adopted a year ago, of surveying the problems needing research in veneer and plywood. It was thought that some progress could possibly be made on one portion of this problem, namely, a survey of research facilities and research programs underway at public and commercial laboratories. The Chairman was authorized to appoint several persons to undertake such a survey.

III. Veneer and Plywood Session at 1957 National Meeting

It was decided to ask the Executive Board that a technical session on veneer and plywood be held during the next FPRS National Meeting in June, 1957, in Buffalo, N. Y.

IV. Membership

No great changes in membership of the veneer and plywood committee are contemplated.

WOOD PRESERVATION—June 5—Chairman, Ira Hatfield, Wood Treating Chemicals Co., St. Louis, Mo.

I. Report on Minutes of 1955 Subject Matter Committee Meeting

Dr. E. A. Behr was appointed temporary Chairman, and was asked to read the minutes of the 1955 Subject

VENEER AND PLYWOOD DIVISION

Matter Committee Meeting. Two items especially covered in the 1955 minutes were discussed, namely, whether the name of the Wood Preservation Committee should be broadened to encompass preservation of other wood products and why the suggested subjects for papers were not covered at this year's meeting.

It was moved by F. J. Meyer that the Executive Committee be asked to give favorable consideration to changing the name to the "Wood Products Preservation Committee". The motion was seconded and passed.

As to why specific papers on "fire retardants, treating of ladders, treating of cooling towers, treating of railroad car lumber, treating of plywood, treating of laminated timbers, treating of furniture and similar items to give dimensional stability, and the treating of composition board" were not covered in this year's sessions, Chairman Hatfield pointed out that because of the timeliness of having papers dealing with prevention of decay and termites in building construction, the Committee voted to have that as its theme and seek speakers and papers on that subject. It was further stated that some of the subjects suggested in 1955 were either being covered by the American Wood-Preservers' Association or were being considered by them (fire retardants, cooling tower treatments, treatment of car lumber), and should not be duplicated by our efforts. A paper on the treating of composition boards was presented by Mr. Meek.

II. Program for 1957 Annual Meeting

It was suggested that there is a wide range of subjects available that would be suitable for papers in 1957. The list includes: new developments in the preservation field, treatment for building lumber, proper building design as a means of preventing deterioration of wood, review of test methods for evaluating preservatives for different end-use products (e.g., fiber boards), and specifications that will insure paintability of pressure-treated wood.

Those interested in wood products preservation were urged to send suggestions either to Hatfield or to the Executive Offices at Madison so that early consideration could be given to them and to selecting a theme for next year's session.

III. Annual Industry Report

The preparation and presentation of the annual report was discussed. Chairman Hatfield asked for comments on several points so that this year's report as presented in typed form at the Asheville meeting could be made more complete before it is published in the Annual Review issue of the Journal in February, 1957. The points discussed were:

1. Should commercial firms or individuals in those firms be mentioned by name in reporting technical activities being undertaken or sponsored by them? The group voted in the affirmative, stating that they are entitled to as much credit for technical work as state or federal agencies or private schools or technological laboratories. A motion to have names of individuals or commercial laboratories included when reporting on work in progress or programs being undertaken was passed.

2. In view of the fact that we had poor foreign coverage of work in progress or of accomplishments and had only a smattering of pertinent literature citations to foreign work, Hatfield raised the question of whether it was better to include what we did have in this incomplete form than to omit it as was done in the preliminary copy of the 1955–56 report.

It was the wish of the Subject Matter Committee that whatever we have on foreign activities be included in

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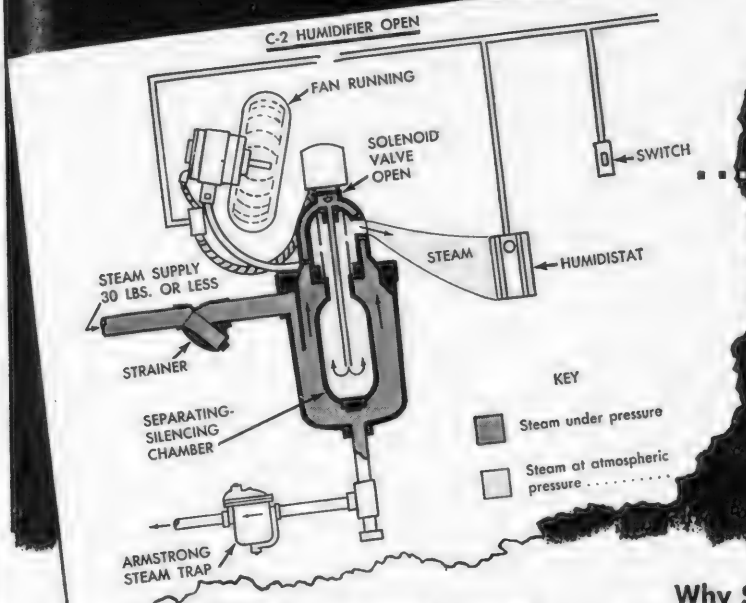

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this year's annual report when it is submitted for publication in the Journal, and that steps be taken to make the annual report as comprehensive as possible in the future. It was pointed out that we have fellow FPRS members in these various world localities, and perhaps we can get some of them to serve on the committee to report on wood preservation progress and literature in their localities. If such members are not found, it was suggested that we try to find other individuals who would be interested in serving in such capacities. Dr. Lindgren stated he would help us find personnel in some of the localities if we wished.

IV. Membership

The Chairman asked for those who were interested in serving on the Committee for 1956–57 to make it known, and said he would welcome suggestions as to others who should be contacted.

The meeting adjourned at 10:10 A. M.

Attending the Wood Preservation Committee Meeting were: Ira Hatfield, Wood Treating Chemicals Co.; M. W. Smith, Hill–Smith Termite Control; E. A. Behr, Chapman Chemical Co.; W. H. Miles, Puget Sound Naval Shipyard; I. S. Goldstein, Koppers Co., Inc.; R. G. Van Allen, Wood Treating Chemicals Co.; W. L. Meek, Minn. & Ontario Paper Co.; W. J. Marshall, Insulation Board Institute; W. B. Clements, Clements' Pest Control; R. S. Taub, Sherwin Williams Co.; G. G. Garlick, Protection Products Mfg. Co.; C. S. Walters, University of Illinois F. J. Meyer, The Dow Chemical Co.; J. S. Ruhoff, Monsanto Chemical Co.; S. H. Wise, Wood Conversion Co.; H. A. Huber, The Dow Chemical Co.; R. M. Lindgren, U. S. Forest Products Lab; George Fahlstrom, Osmose Wood Preserving Co.; M. M. Lehrbas, Southern Forest Experiment Station; C. R. Lockard, U. S. Forest Service; H. W. Doyle, Darworth, Inc.; N. E. Kittell, Joslyn Mfg. & Supply Co.; G. E. Olson, The Dow Chemical Co.; R. G. Wallace, Western Electric Co.; C. M. Burpee, Amer. Wood Preserving Institute; Ray Osborne, Amer. Wood Preserving Institute; W. C. Kelso, Chapman Chemical Co.; P. B. Mayfield, Barrett Div., Allied Chemical & Dye Corp.; T. R. Mickels, Vestal Lumber & Mfg. Co.; R. D. Dixon, Osmose Co.; and J. H. Secor, Jr., The Dow Chemical Company.

GLUES AND GLUING—June 6—Chairman, Alan A. Marra, University of Michigan, Ann Arbor, Mich.

The meeting was opened at 9:30 A.M. by Chairman Marra. Ben S. Bryant served as Secretary.

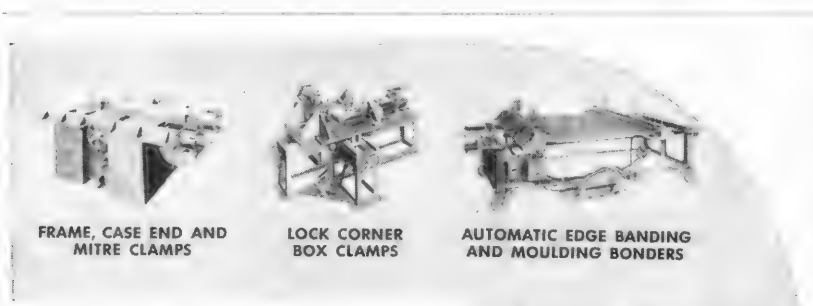
Dr. Marra discussed the objectives of the Division in planning technical sessions and gathering information for the whole membership, and outlined a committee organization which could best serve these purposes. The Division will operate under the guidance of a Steering Committee composed of a small group appointed to cover the designated segments of the field. The work of the Division has been divided into nine areas, each administered by a chairman and staffed by specialists who are in a position to contribute time and knowledge to the work. Following is the organization as it is presently drawn. The membership of the Society is invited to review the list of subcommittees and sections and consider whether they wish to participate. Those that feel they can contribute should contact the chairman of the Division or the chairman of the particular subcommittee in which he is interested.

The following subcommittees and sections were proposed:

I. Adhesives — R. F. Blomquist, U. S. Forest Products Lab., Chairman. Section a) plywood adhesives; b) assembly adhesives; c) laminating adhesives; d) dissimilar materials adhesives; e) extenders; f) modifiers; g) selection and performance.

II. Gluing Techniques and Glued Products — *C. F. MacLagan,* Borden Co., Chairman. Section a) veneering; b) laminating; c) assembling; d) combination materials.

III. Methods of Test—John Butler, Hardwood Plywood Institute, Chairman. Section a) strength tests; b) accelerated durability tests; c) long



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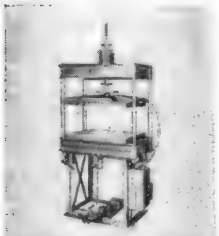

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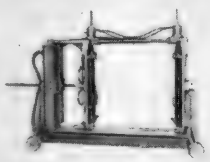

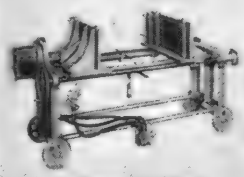

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time durability tests; d) service observations; e) specifications.

IV. Gluing Equipment — Robert Williams, American Marietta Co., Chairman. Section a) storage and handling; b) mixing; c) spreading; d) pressing; e) heating.

V. Current Research — James S. Bethel, N. C. State College, Chairman. Section a) basic research relating to wood; b) basic research relating to adhesives; c) development research.

VI. Patents — D. B. Richards, Alabama Polytechnic Institute, Chairman.

VII. Bibliography — Ben S. Bryant, University of Washington, Chairman. Section a) books; b) articles.

VIII. Technical Sessions — Division Vice-Chairman, R. F. Blomquist, Chairman.

IX. Annual Review — Alan A. Marra, University of Michigan, Chairman.

In order to assure progress in all directions, a vice-chairman was appointed and given the important task of organizing the technical session for next year. Dr. Richard F. Blomquist was named to this post. He is head of the Glues and Gluing Section of the U. S. Forest Products Laboratory, Chairman of Committee D-14 on Adhesives in the American Society for Testing Materials, Chairman of the 1956 Gordon Conference on Adhesion in the American Association for the Advancement of Science, and the author of numerous articles on adhesives.

John Ritchie suggested that the membership of the Division be sent a questionnaire for suggestions as to people who would be effective sources of information. Dr. Bryant added that space should be allotted for suggestions for National Meeting papers.

Thoughts were shared as to whether or not the scope of the Division should include paper adhesives. The consensus of the group was that wood must be one of the components in the adhesive bond. T. R. Truax suggested that this would be a good starting point.

Program for 1957 National Meeting

The group agreed to have a technical session next year. Criticism of past papers was made. The group agreed that all papers must be reviewed before acceptance or presentation. Sentiments included: avoiding inaccuracies; avoiding promotional papers; more emphasis on mechanical details; a panel discussion. The group approved the panel discussion approach.

Dr. Bryant suggested that for one session, two papers (e.g., a research paper and an application paper) and one panel discussion would be maximum.

D. Redfern suggested a panel on automation. Other subjects suggested were: automatic gluing and spreading, mixing and spreading techniques. The general area of new or automatic equipment and techniques in mixing and spreading and glued assembly layup was discussed.

Suggestions were made for moderators for next year's session.

The meeting adjourned at 10:50 A.M.

Attending the meeting were: Don Redfern, American Marietta Co.; J. L. Hill, Alabama Polytechnic Inst.; Jorge Gonzalez and Theodore Bailey, Theodore Bailey & Co.; R. C. Gill and C. E. Lehmann, Peter Cooper Corp.; R. F. Blomquist and T. R. Truax, U. S. Forest Products Lab; J. D. Ritchie, Douglas Fir Plywood Assn.; F. H. Kaufert, University of Minnesota; J. M. Hine, The Borden Co.; L. P. Wahl, Archer Daniels Midland; R. A. Yerger, Wood-Metal Co.; N. Reimer, Monsanto Canada, Ltd.; J. L. Butler, Hardwood Plywood Inst.; E. R. Heagh, General Electric Co.; H. A. Huber, Dow Chemical Co.; E. A. Anderson and J. M. Yavorsky, State University of New York College of Forestry; R. L. Hiller, American Cyanamid Co.

CHEMICAL UTILIZATION—June 6—Chairman, Reavis C. Sproull, Philip Morris Co., Richmond, Va.

Chairman R. C. Sproull welcomed and introduced those attending. Duane Kenaga served as Secretary

I. Report on Last Year's Work

Special papers published in FPRS Journal—Review of Chemical Utilization, Dr. E. G. Locke.

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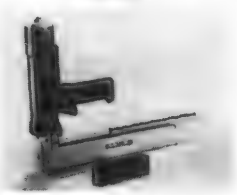

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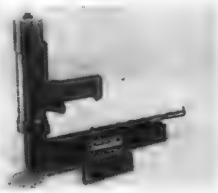

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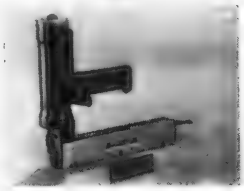

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Chemical utilization session at 10th Annual Meeting — Chairman was pleased with response to solicitation for papers.

Bibliography by Dr. Jean Mater on "Effects of Special Energy Treatments of Cellulose," turned over to Publications Committee.

II. Promotion of "Wood Section" in Chemical Abstracts

Report of committee by Dr. Locke —No significant results to report. Dr. Locke talked with Mr. Hackett in Columbus, Ohio in the absence of Dr. Crane. Letters were written by Dr. Locke and Dr. Gregory to Dr. Crane.

Discussion—Dr. Sproull suggested letters from industry representatives would help. Dr. Locke agreed and suggested that personal contact also be made. Dr. Saeman suggested that in lieu of a wood section, the cellulose section be expanded to include "b" section summarizing all wood papers with chemical implication. Dr. Gregory suggested that footnotes or cross-references might be added.

Dr. Pearl indicated that the representatives of the Paper Institute have fought a losing battle over this for years. He didn't foresee much success. Dr. Woodruff volunteered to talk with Dr. Crane. Dr. Locke suggested the argument be used that increased chemical activity in the bark and lignin fields will be lost if a proper section is not designated. Mr. Meyer said he would talk with Dr. Nutting of Dow Chemical, who has considerable influence with this activity of ACS.

Appointment of a new committee—The following committee was appointed with approval of the new Chairman of the Chemical Utilization Committee: Chairman—S. A. Woodruff, Battelle Memorial Inst.; A. S. Gregory, Weyerhaeuser Timber Company; F. Meyer Dow Chemical Co.; F. Perry, A. D. Little Co.; and E. G. Locke, U. S. Forest Products Laboratory.

III. Chemical Utilization Session at 11th Annual Meeting

Suggestions were made for more industry papers as contrasted with institutional papers. Members attending agreed to hold session.

Type of session—Dr. Locke suggested a program of papers for ½ day and a symposium for another ½ day, the latter program to be highly technical. It was mentioned that Buffalo was a desirable area for such a program as there were several groups in the vicinity who should be interested. Dr. Sproull and Dr. Gregory supported the suggestion of Dr. Locke. No objections were forthcoming and the two-session program was approved as a request to the General Program Committee.

Committee Appointed to be in Charge of Chemical Utilization Session, 1957 Annual Meeting: Chairman, A. S. Gregory, Weyerhaeuser Timber Co.; I. Pearl, Institute Paper Chem.; F. Perry, A. D. Little Co.; R. Cairns, Hercules Powder Co.; D. Kenaga, Dow Chemical Co.

IV. Review of Committee Chairmen Meeting (by Dr. Sproull)

Scope and functions of committees —It was voted to recommend that the names be changed to Divisions with steering committees to transact business of the Divisions.

Strong general session—Committee chairmen were disturbed by poor attendance at the opening session of the National Meeting. It was recommended that the program at future national meetings open with a strong general session which would include speakers of national reputation. The President–Elect would have direct responsibility for this session with aid and participation of the committees.

Who are members of the committees? It was resolved that any person interested and willing to do some of the work of the Society through the established system of committees may be a member.

V. Expenses Associated with Committee Activities

L. Wallace suggested a regular fund be established from nominal division dues. This would facilitate bet-

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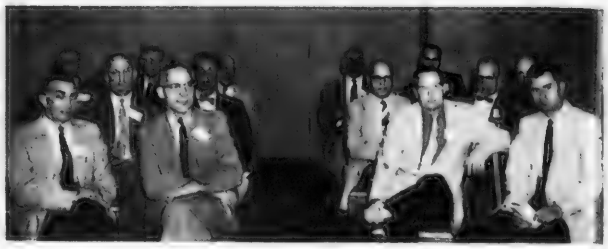
CHEMICAL UTILIZATION DIVISION



WOOD DRYING DIVISION

ter distribution of bibliographies and aid in carrying out duties of the Committee. Dr. Sproull indicated that to date expenses have been nominal, and have in general been borne by the employers.

Dr. Locke reviewed past action, pointing out that committee rather than division names had been kept for fear of dividing the Society into special groups. A nominal sum is set aside to service the committee work. If the group deemed dues desirable, he could make recommendations to W. J. Eason, Vice-President. It was resolved that as the scope of the committee grew, it might be necessary to request funds for committee activities.

VI. Binding for Committee Reprints

A uniform binding for committee reprints was left for further action.

VII. Completion of Bibliographies

Bark—S. A. Woodruff will undertake this if he can gain clearance of Batelle sponsor. L. Wallace will aid on cork section.

Pyrolysis—R. C. Sproull will complete bibliography on pyrolysis.

Others suggested — pectins, hemicelluloses, analytical techniques for various wood fractions.

Dr. D. F. Durso, Buckeye Paper, Memphis, may be able to compile one on analytical techniques of carbohydrates.

VIII. Annual Report for Review Issue of the Journal

Past experiences of chemical utilization field — Sections have been done in part by several people and the report edited by Dr. Locke.

Subdivision of given areas was discussed. Trend is in this direction but action now is somewhat premature.

Review as part of opening session of national meeting—L. Wallace suggested the reviews be a part of the opening session mentioned above. It was pointed out that the present policy and status of the Review Issue would be upset.

IX. New Officers of Chemical Utilization Committee

Chairman — Dr. E. G. Locke, U. S. Forest Products Laboratory; Vice-Chairman—Dr. A. S. Gregory, Weyerhaeuser Timber Co.

Attending the meeting were: W. I. Lyness, Procter and Gamble Co.; F. G. Perry Jr., Arthur D. Little, Inc.; L. C. Wallace, Crown Cork & Seal Co.; I. A. Pearl, Institute of Paper Chemistry; F. J. Meyer, Dow Chemical Co.; J. A. Hauter, Allan Wood Products Co.; J. F. Saeman, U. S. Forest Products Lab; S. A. Woodruff, Battelle Memorial Institute; J. P. Foley, Weyerhaeuser Timber Co.; A. W. Williams, Shell Chemical Corp.; T. E. Werkema, Dow Chemical Co.; H. W. Doyle, Darworth, Inc.; H. M. Tobey, Dow Chemical Co.; H. M. Ely, Potlatch Forests, Inc.; A. S. Gregory, Weyerhaeuser Timber Co.; E. G. Locke, U. S. Forest Products Lab; F. F. Wangaard, Yale University School of Forestry; C. C. Heritage, Consultant, Tacoma, Wash.; F. H. Kaufert, U. of Minnesota School of Forestry; E. T. McCarthy, American–Marietta Co.; R. C. Sproull, Philip Morris Co.; D. L. Kenaga, Dow Chemical Co.

WOOD DRYING—June 6—Chairman, L. D. Espenas, Oregon Forest Products Laboratory, Corvallis, Ore. Acting Chairman, Ray Rietz, U. S. Forest Products Lab., Madison, Wis.

Ray Rietz presided in the absence of the Chairman. J. D. Snodgrass served as Secretary.

I. Wood Drying Division News Digest

Mr. Rietz reviewed the preparation and distribution of the News Digest articles, mentioning briefly the subject covered in each article. So far, there has been an article each month. A sur-

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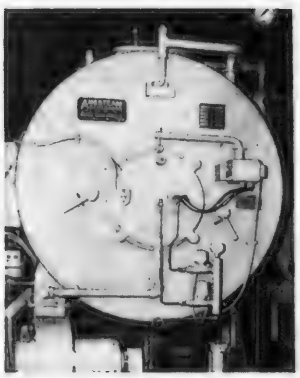

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vey of stickers by Frank Cook which was expected for the technical session would be a good subject for a future issue but the survey could not be completed in time for the Asheville meeting. Papers by Willard Pratt and Roy Carter presented at the technical session, however, are good possibilities for future issues. Division members were invited to submit articles for consideration.

At the present time, the subject matter for the News Digest is handled through a subcommittee headed by Ray Rietz with Steve Preston and Leif Espenas as members. The program has been quite successful, and is given enthusiastic support by the Society. Fred Dickinson urged that the Division go on record of congratulating and supporting Mr. Rietz for the work he has done in preparing and distributing the articles. Mr. Rietz pointed out that publication of articles in the "News and Views" series of the U. S. Forest Products Laboratory can also be a means of getting information out to help kiln operators.

During the discussion of the News Digest articles, the subject of representation of the kiln clubs in the Wood Drying Division was also discussed. Mr. Rietz presented the possibility of kiln club officers automatically becoming members of the Wood Drying Division. This would encourage kiln club members to participate in the activities of the FPRS, although some club members are also FPRS members. It was proposed that the Division recommend to its Chairman the consideration of inviting kiln club secretaries to work on the Wood Drying Division and to encourage them to become FPRS members.

II. Wood Seasoning Lecture

Fred Dickinson reviewed the progress and status of the seasoning lecture. Since the Wood Drying Division could not find adequate means of providing an honorarium, the idea was broadened in scope to include the entire field of forest products and was recommended to the FPRS Executive Board in March 1955. The Board approved the principle of the venture but financing is still a major problem. So far as is known, no progress has been made this past year.

Hereford Garland mentioned the possibility of the kiln clubs contributing to pay a lecturer, but others pointed out that kiln club funds are limited. Another idea suggested was that this might be an FPRS Section responsibility. Mention was also made of the possibility of a lecturer in seasoning touring the country to give the lecture to the various clubs or to joint FPRS Section and kiln club meetings.

III. Program for 1957 National Meeting

The Division decided in favor of having a technical session at the 1957 annual meeting. Possible authors and papers mentioned for the meeting were: J. L. Ladell of the Canadian Laboratory on high temperature drying; C. Skaar of the College of Forestry, State University of New York; R. Page on a survey of air drying practices; Lon Gaby on pre-drying; John McMillen, USFPL, on drying stresses in softwoods; Frank Cook's survey on stickers; John Devine; C. R. Lockard has done some work on pre-drying; a nation-wide panel on sticker use, costs, etc.; and Steve Preston on effects of time and temperature on set in wood.

The Division recommended that the Chairman appoint a committee from the Buffalo and nearby area to arrange the technical session. A suggestion was made that preprints be supplied or that perhaps authors could supply copies of their papers.

IV. Division Activities for the Coming Year

Division activities for the coming year were discussed. Assignments to members for a bibliography covering the literature during 1955 had been made. Mention was made of a list

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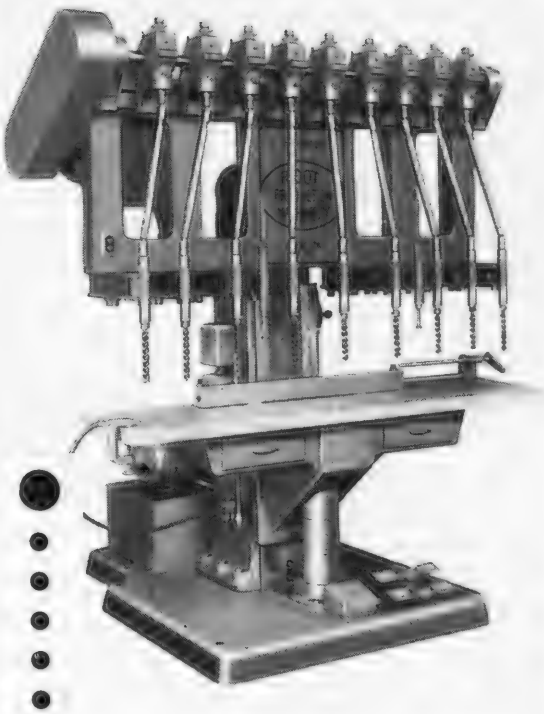

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that had been compiled of needed research and data in the field of seasoning, some of which could be obtained by kiln clubs. In connection with this, Mr. Rietz told of tentative plans at the Laboratory in Madison to hold a seasoning research conference some time in the next year to assess fundamental and applied research needs.

V. Annual Industry Report

Regarding an annual report, there may be special subjects that could be developed such as instrumentation, high temperature drying, etc. Other possibilities for inclusion may be contributions of literature review by schools, special subjects covered in kiln club meetings, and research projects by kiln clubs.

VI. Other Business

Some notes were read reviewing the Chemi-Dry process. William Delmhorst discussed his kiln control equipment. The principle in this is to use electrical resistance as such and through local research to relate this to weights and moisture content.

LOGGING AND MILLING—June 7—Chairman, Fred C. Simmons, Northeast Forest Experiment Station, Upper Darby, Pa.

Chairman Simmons opened the meeting at 9:00 A.M. David E. Herrick served as Secretary.

I. Report on the Annual Meeting of the Subcommittee on Sawmilling

Report was read by Peter Koch, Michigan State University, East Lansing, Mich. E. P. Ivory moved that the subcommittee report be adopted as read. N. C. Bye seconded, and the motion was carried by a unanimous vote.

II. Committee Organization

Chairman Simmons reported that several committee and Society members have suggested that the present committee be split to form two full committees—one on logging and one on sawmilling or lumber manufacture. He solicited the opinion of committee members on this matter. In the ensuing discussion it was pointed out that:

A. Logging and milling are each large, complex fields and many groups are interested mainly in one or the other. As a result, only a part of our technical programs are of fundamental interest to many of those in our audience.

B. There is too much subject matter in the two fields to be covered adequately during one technical session. By trying to cover both we tend to dilute the effectiveness of our program.

It was informally agreed that Chairman Simmons should recommend to the Executive Board that the present committee be split to form two committees—one on logging and one on sawmilling.

Mr. Simmons reported that the Subject Matter Committee Chairmen in a previous meeting had already recommended to the Executive Board that the Subject Matter Committee setup be abandoned, and that instead the Society be organized into Subject Matter Divisions. Every member of the Society would automatically be a member of the Division or Divisions of his choice. Each Division would have a Chairman and Vice-Chairman and a small Steering Committee. This recommendation and the recommendation that separate Logging and Lumber Manufacture Divisions be established was subsequently acted upon favorably by the Executive Board. Mr. Simmons was appointed Chairman of the Logging Division with Paul Dunn as Vice-Chairman. Milton Mater was appointed Chairman of the Lumber Manufacture Division with E. P. Ivory as Vice-Chairman.

III. Committee Activities

Robert Hoyle reminded the group that one objective of the Society is to help promote, guide, and coordinate forest products research. As a first step toward meeting this objective he moved that our committee develop a list of proposed sawmill studies and assign a priority to each. He said such a list would help research groups attack milling problems in the order of their importance. Mr. Mater seconded Mr. Hoyle's motion and the vote for adoption was unanimous. Chairman Simmons appointed N. C. Bye chairman of a committee to develop a list of such studies.

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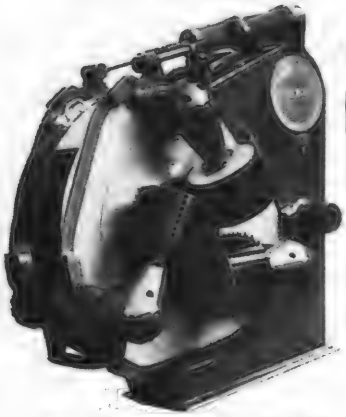

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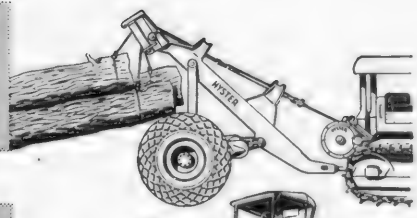

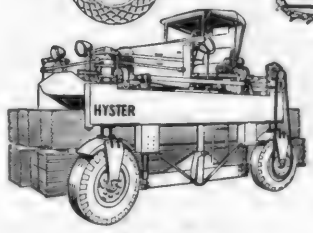

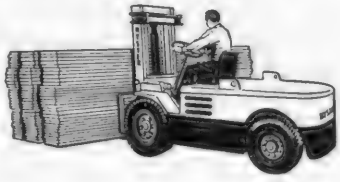

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LOGGING AND MILLING DIVISION
(now separate divisions)

WOOD MACHINING DIVISION

The group recommended that if we have both a logging and a lumber manufacture committee next year, each should plan to conduct a technical session at the 1957 annual meeting. It was tentatively decided that the Lumber Manufacturing Division Session would be devoted to "Quality Control in the Sawmill".

E. P. Ivory moved that a list of sawmill improvements from all over the U. S. and contiguous sections of Canada be compiled periodically by the committee and published as a news column in the FPRS Journal. N. C. Bye seconded this motion and it was unanimously adopted.

M. H. Mater moved that the Committee co-operate with the ASME N.W. Section Wood Products Committee on Sawmill Nomenclature, to the end that standard terminology could be set up for all phases of sawmilling. G. E. Bell seconded the motion and it was passed unanimously.

Attending the meeting were: Fred C. Simmons, Committee Chairman, N.E. Forest Experiment Station; Milton H. Mater, Mater Engineering; E. P. Ivory, Ivory Pine Co.; Peter Koch, Michigan State University; N. C. Bye, Disston Div., H. K. Porter Co.; R. P. BaRoss, Forestry Rep., Caterpillar Tractor Co.; W. W. King, Forest Investigations Branch, TVA; R. J. Hoyle, State University of N. Y., College of Forestry; John W. Lehman, Forest Util. Sect., For. Div. TVA., J. B. Carpenter, Enterprise Co.; L. R. Pugh, St. Maries Lumber Co.; G. E. Bell, FPL of Canada, Ottawa; F H. Kaufert, University of Minnesota; Hereford Garland, Mich. College of Mining and Technology; Paul Dunn, St. Regis Paper Co.; and David E. Herrick, Central States For. Exp. Station.

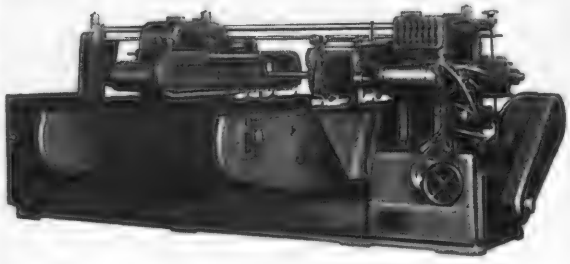
WOOD MACHINING—June 7—Chairman, Louis A. Patronsky, The Wabash Screen Door Co., Minneapolis, Minn.

The meeting was called to order by Chairman L. A. Patronsky. Norman C. Bye, former secretary of the Wood Machining Committee, was asked by Chairman Patronsky to serve as Vice-Chairman. T. C. Weill was then appointed to serve as Secretary.

I. Program for 1957 National Meeting

The following subjects were suggested for papers to be presented at the Wood Machining Session in 1957:

1. Machining composition boards. Work on this subject has been done



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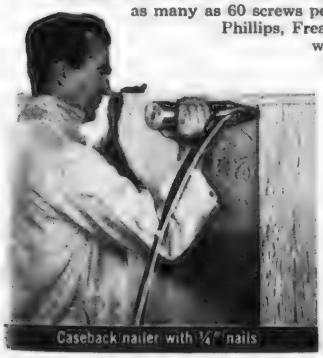
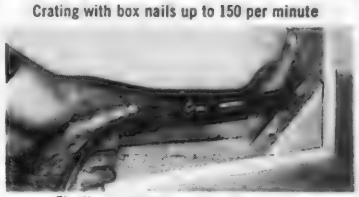


Caseback nailer with ¼" nails

Nailer B feeds and drives up to 16d

Crating with box nails up to 150 per minute



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2. Heat generated in the tool during the machining of wood. R. J. Hoyle, Jr., N. Y. State College of Forestry, has done some work on this subject and plans to do more before the 1957 meeting.

3. Wide belt sanding of wood parts and assemblies — suggested by P. F. DeSaix. Contact The Carborundum Co., Curtis Machine Co., Minnesota Mining and Manufacturing, and Timesaver Co. for possible papers on the subject.

It was moved that other subjects be obtained from those committee members who were unable to attend the meeting. This should be done during September and October, 1956.

II. Facilities for the Wood Machining Technical Session at Asheville

The group was of the unaminous opinion that the facilities for the wood machining session at Asheville were unsatisfactory. Specific critcisms were:

1. The auditorium was too large for the attendance making it difficult to hear because of small audience in huge auditorium.

2. The last paper on the session was heard by only 15 to 20 people because of the conflict with the scheduled "Paul Bunyan Barbecue" in the Great Smoky Mountains National Park. The committee urged that in the future social events be scheduled so as not to interfere in any way with the technical sessions. In this case those planning to attend the barbecue had to return to their hotels before noon to obtain proper clothing for the outdoor activity.

3. Facilities for projection of films and slides were poor. Blackout was impossible in the large room.

III. Nomenclature of Saws and Knives

The committee reviewed progress on nomenclature of saws and knives. A mail report was deemed essential because most of the members of these committees were absent.

The meeting adjourned at 4:30 P.M.

COMPOSITION BOARD—June 7—Chairman, George G. Marra, Washington State Institute of Technology, Pullman, Wash.

The Chairman opened the meeting at 2:00 P.M. J. R. Roberts served as Secretary.

I. Plans for the 1957 National Meeting

Discussion centered on the development of timely topics on which to base a technical session on composition boards for the 1957 national meeting. The discussion brought out that the most important need of the industry appeared to be that of clarifying standards for this class of materials.

The role of N.W.M.A., A.S.T.M. and I.B.I., as well as the British Standards Institute were discussed. The role of FPRS also was debated with some consensus that it should continue to act as an information-dispersing agency rather than a promulgator of standards. To this end, a paper on this subject should be sought for the Buffalo meeting.

Other topics which developed a lively discussion during this open meeting were:

1. Comparison of European processes with American processes. A succinct statement was made that usually good and bad boards can be made by any process depending upon the capabilities or inclinations of the operators.

2. Progress of adhesive companies toward the development of a low-cost adhesive which would impart exterior properties to a board. Adhesive representatives felt that progress in this direction would have to be preceded by precise specifications regarding the final product. Cost might be high.

3. Basic engineering in a particle board plant.

4. Limitations of urea resins in particle board.

5. Use requirements for building standards which at present limit the use of composition board in housing. It was noted that the insulation board

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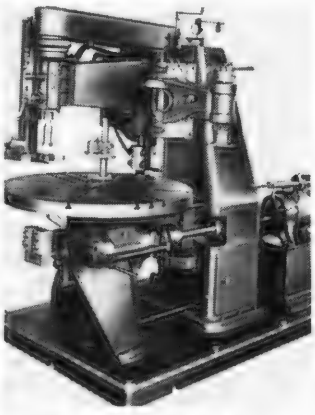

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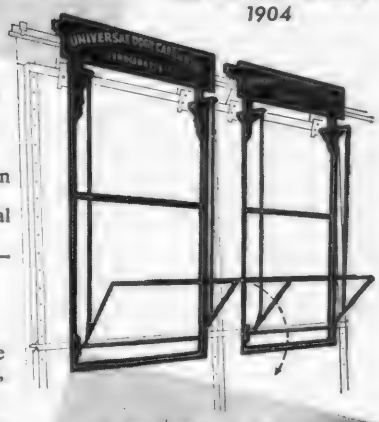

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10. Factors affecting resin efficiency in particle boards.

11. Desirability of avoiding conflict between open committee meetings and technical sessions.

WOOD FINISHING — June 7 — Chairman, E. S. Johnson, North Carolina State College, Raleigh, N. C. Presiding Chairman, F. H. Thomas, Sherwin Williams Co., Chicago, Ill.

The following men were recommended for appointment for the coming year: Chairman, F. H. Thomas, Sherwin Williams Co.; Vice-Chairman, D. G. Lubeck, Hammond Organ Co.

The Committee voted to extend its appreciation to E. S. Johnson, retiring Chairman, for the excellent technical session held that morning on "How to Select a Better Finish for Furniture.

I. Program for Wood Finishing Technical Session at 1957 National Meeting

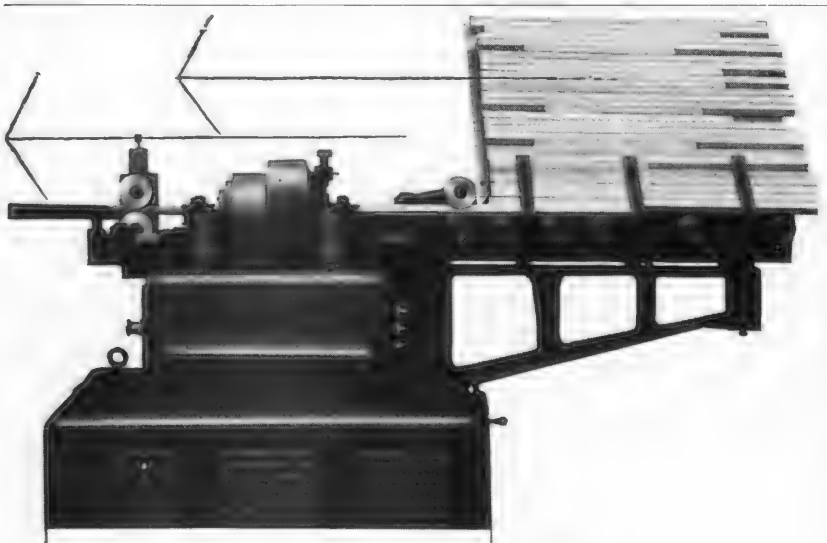
It was unanimously decided to hold a technical session at the National Meeting in Buffalo, N. Y. next June. Various subjects were suggested which will be covered later in a letter to all members of the Steering Committee by Don Lubeck, Vice-Chairman.

II. Joint Industries' Furniture and Finishes Committee

There was considerable interest expressed by those present in the Joint Industries Furniture and Finishes Committee recently formed by the wood finishes and furniture manufacturers.

It was felt that some of their undertakings might be suitable subject matter for presentation and discussion at our meetings. A resolution was passed authorizing the Chairman to write to the Chairman of the Joint Industries' Committee expressing this committee's interest.

In order that members of the Steering Committee would have a better understanding of the Joint Industries action, copies of the National Paint, Varnish and Lacquer Association's report of February 27, 1956, the NAFI Summary of Finishing Problems, and the Minutes of the Organizational



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Meeting, April 24, 1956, were made available to them. Highlights of these reports are:

The furniture finishes inter-association committee is the culmination of extended efforts to present finish manufacturers' plans for improved furniture finishes to top management level in the furniture industry. Co-operating in this, NAFM representatives furnished a copy of a report on a recent nationwide study of "furniture manufacturers' finishing problems." This report indicated that the most important problems are: 1. color control —the need for developing uniformity of finish from one production cutting to another; 2. keeping up-to-date with color and finishing trends; 3. training and supervising of finishing personnel; 4. need for better technical information on wood preparation, i.e., sanding, sealing, filling, etc.; 5. reducing cost of materials and time of finishing operation; and 6. developing more durable finishes.

Important among the actions approved in the Joint Industries Furniture and Finishes Committee organizational meeting was that the first project of the Committee be a revision of National Paint, Varnish and Lacquer Association's circular, "Control Testing Methods for Wood Finishes," to bring it up-to-date and make it appealing to furniture manufacturers.

EMPLOYMENT — June 3 — Chairman, Newell A. Norton, Pennsylvania State University

The major activity of this committee again has been the Summer Placement Program for college students enrolled in curricula in forestry and forest products technology. While complete returns for this year's program will not be available until later in the summer, the committee's efforts have certainly been much more successful than those of last year and for the most part encouraging. The Forest Products Research Society has succeeded in providing the necessary channel to bring the student and industry together although some improvements are certainly needed if an efficient service is to be provided.

The problem of obtaining lists of firms for each region was assigned to the individual members of the committee and through their efforts 78 firms agreed to cooperate in the Summer Placement Program. Incomplete returns from the educational institutions show that some firms, for one reason or another, were unable to carry out their commitments.

Forty-two educational institutions are on the committee's mailing list. Cooperation was not as enthusiastic as was expected, but after repeated efforts a reply concerning the program was obtained from most of them, although a few neglected to acknowledge any of the correspondence.

Since returns from the institutions are incomplete at this time, only fragmentary data on the number of students using the service can be given. Ten institutions report a total of 63 students using the service. Of these 16 obtained summer jobs. Thirteen students did not accept employment when offered. This number may well be higher. Four schools reported 38 men interested in the program, but no report has been received as yet concerning the number of men actually using the service or the number of jobs accepted. Seventeen institutions, for one reason or another, did not cooperate this year, although many of these expressed interest and hope to be able to do so in the future.

Permanent placement is handled by the Madison Office. Frank J. Rovsek, Executive Secretary, reports:

1. Number of firms which have contacted the Placement Service for men since the last annual meeting in Seattle—52.
2. Number of experienced personnel contacting the Madison Office for new positions since that date —42.
3. Number of recent college graduates who have used the service since that date—15.

Eleven more firms used the service since the last annual meeting than in the previous year. The number of recent college graduates increased by eight for the corresponding period. The use of the service by experienced personnel seeking new jobs shows almost no change.

To the present committee members, Roy M. Carter, Eldon A. Behr, Harvey H. Smith, Richard W. Petterson, and E. R. Martell, the Chairman wishes to express his appreciation and thanks for their cooperation and hopes that they will continue to serve the Society in their present capacity during the coming year.

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With a membership of over 3100 persons as this Yearbook issue goes to press, the national work of FPRS is administered by elected Executive Board comprised of four officers and six regional board members. The sectional work is governed by 100 officers and trustees. The various administrative and subject matter committees add another 225 names to the work of the Society.

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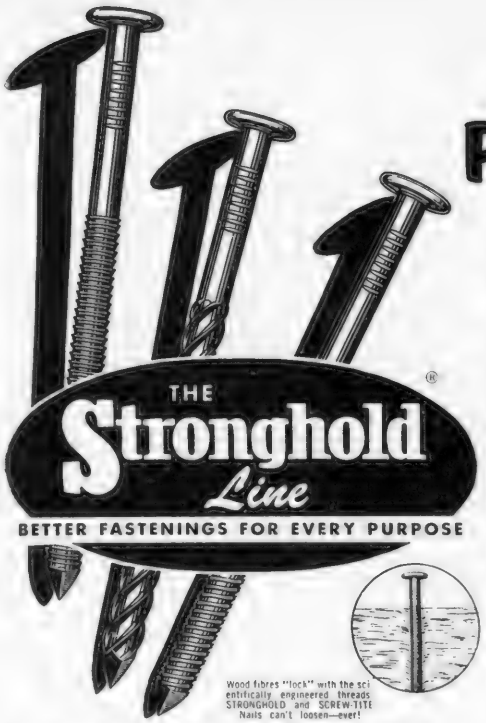
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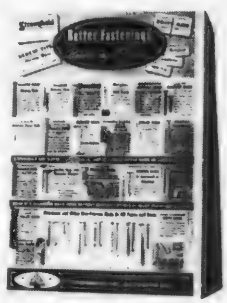

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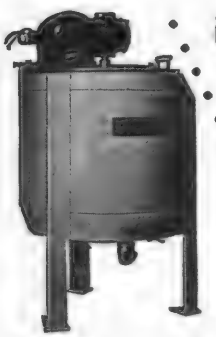

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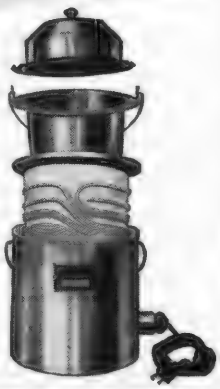

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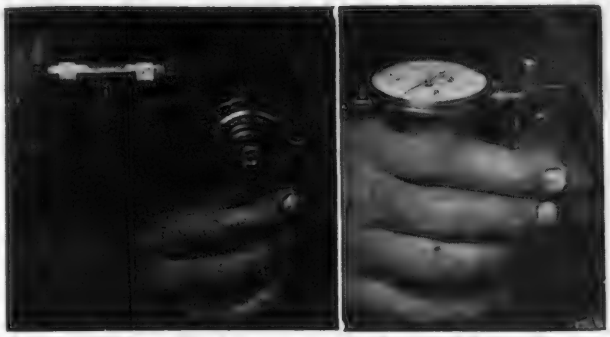

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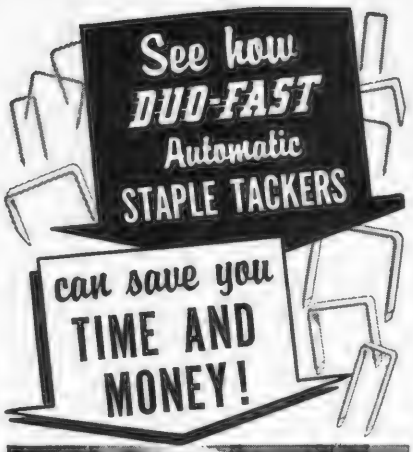

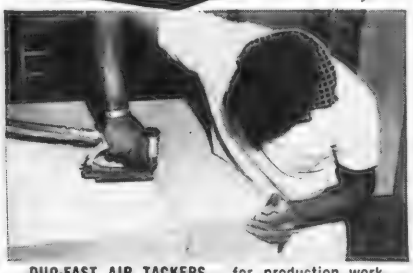

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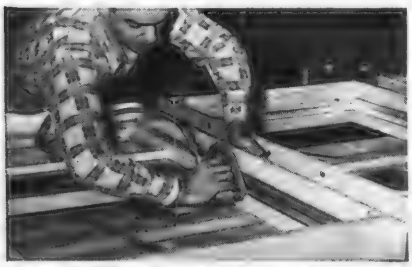

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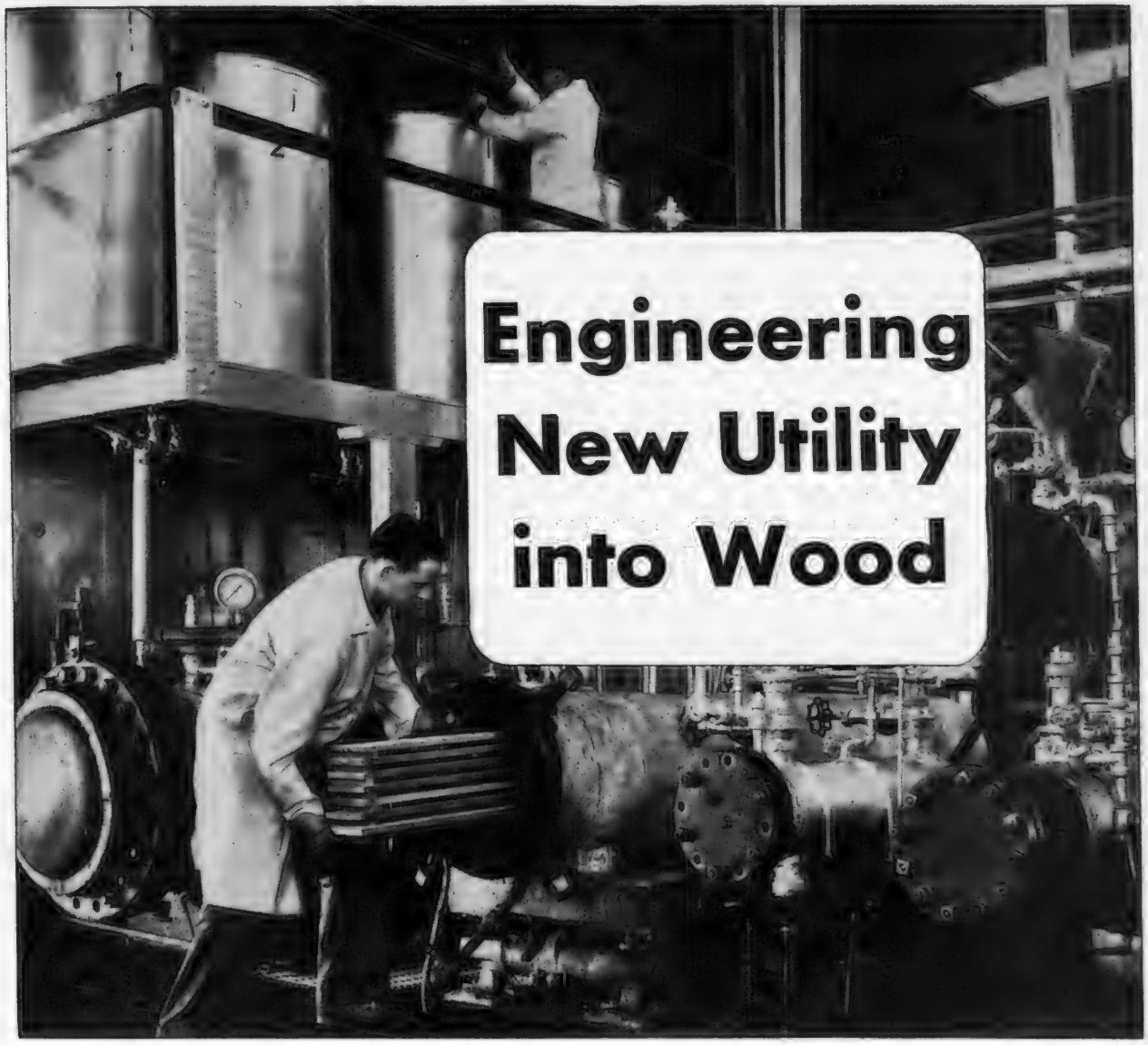

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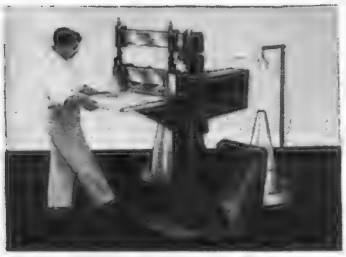

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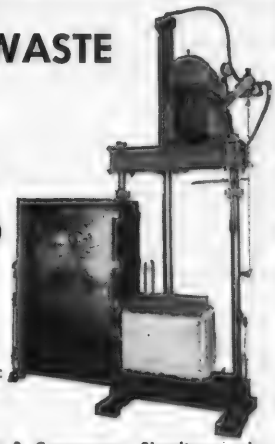

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Victor H. Clausen, Rt. 1, Box 344A, Eureka, Calif.

Pat Williams, Jr., Moore Dry Kiln Co., Box 4248, Jacksonville 1, Fla.

E. D. Marshall, 541 Humason Ave., Lufkin, Texas.

Harold Rhodes, J. W. Bolton & Sons., Lawrence, Mass.

Harold B. Gatslick, State University College of Forestry, Syracuse 10, N. Y.

F. W. Guernsey, Forest Products Laboratory, University of British Columbia, Vancouver, B. C., Canada.

H. J. M. Jorgensen III, Jorgensen-Bennett Mfg. Co., Box 4605 North Station, Memphis, Tenn.

Paul H. Lane, U. S. Forest Service, Mirman Bldg., Wausau, Wis.

R. S. Millett, Forest Products Laboratories, Ottawa, Ont., Canada.

Harvey H. Smith, California Forest & Range Exp. Sta., P. O. Box 245, Berkeley 1, Calif.

WOOD FINISHING

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Vice Chairman—D. G. Lubeck, Hammond Organ Co., 2915 North Western Ave., Chicago 18, Ill.

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P. F. De Saix, Carborundum Co., Box 1574, High Point, N. C.

Cornelius Reckers, Georgia-Pacific Plywood Co., Inc., Olympia, Wash.

Willard Pratt, California Redwood Assoc., 576 Sacramento St., San Francisco 11, Calif.

T. E. Werkema, Dow Chemical Co., Midland, Mich.

Don E. Laughnan, U. S. Forest Products Lab., Madison, Wis.

F. L. Browne, U. S. Forest Products Lab., Madison, Wis.

A. J. Wandersleben, United Cooperatives, 2423 E. Main St., Alliance, Ohio.

George A. Lenaeus, Southern Varnish Corp., P. O. Box 1004, Roanoke, Va.

Carl E. Rasmussen, Western Pine Assn., 7733 S. E. 13th Ave., Portland 2, Ore.

Robert S. Taub, Sherwin–Williams Co., 601 Canal Road, Cleveland 13, Ohio

R. B. Shurts, National Paint, Varnish & Lacquer Assn., 1500 Rhode Island Ave., N.W., Washington 5, D. C.

Thomas H. Moran, Douglas Fir Plywood Assn., 1119 A St., Tacoma, Wash.

WOOD MACHINING

Chairman—L. A. Patronsky, Wabash Screen Door Co., 2222 S. E. Elm St., Minneapolis, Minn.

Vice Chairman — N. C. Bye, Henry Disston Div., H. K. Porter Co., Inc. of Pittsburgh, Unruh & Milnor Sts., Philadelphia 35, Pa.

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Donald E. Flinchbaugh, York, Pa.

R. S. Crowder, Johnson-Crowder Co., 3906 N. 14 Ave., Birmingham, Ala.

P. F. De Saix, Box 1574, High Point, N. C.

Rust Gray, Graycon Tools, Inc., Box 334, Wabash, Ind.

R. D. Brooks, Carbide Saw & Tool Div., R. Hoe & Co., Inc., High Point, N. C.

WOOD PRESERVATION

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Vice Chairman — Charles S. Walters, Illinois Agric. Exp. Station, 219 Mumford Hall, Urbana, Ill.

L. A. PATRONSKY

I. HATFIELD

Advances in Methodology of Applying Preservatives and Advances in Test Methods or Techniques

Pressure Field and Solvent Recovery:

M. S. Hudson, P. O. Box 2451, Spartanburg, S. C.

Pressure Field and Other Treating Methods:

J. A. Greenwald, Jr., Box 525, RFD 5, Tampa, Fla.

Other Than Pressure or Hot-cold Methods:

G. G. Garlick, Protection Products Mfg. Co., Box 747, Kalamazoo 99, Mich.

Conventional AWPA Methods:

P. B. Mayfield, Barrett Division, Allied Chemical & Dye Corp., 40 Rector St., New York, N. Y.

Test Methods for Preservatives:

Ralph Van Allen, Wood-Treating Chemicals Co., 5137 Southwest Ave., St. Louis, Mo.

New Chemicals Proposed for Wood Preservation or New Adaptations of Old Chemicals

J. O. Blew, U. S. Forest Products Lab., Madison 5, Wis.

F. J. Meyer, Dow Chemical Co., Midland, Mich.

R. A. Zabel, New York State College of Forestry, Syracuse 10, N. Y.

Wood Preservation Activities by Regions for 1955-56

Northeastern United States

H. W. Hicock, Conn. Agric. Exp. Sta., Box 1106, New Haven, Conn.

Mid-Continent

Miles Burpee, American Wood Pres. Inst., 111 W. Washington St., Chicago 3, Ill.

E. A. Behr, Chapman Chemical Co., Mallory Sta., Box 3158, Memphis, Tenn.

South and Southeast

Mark Lehrbas, Southern Forest Exp. Sta., 2026 St. Charles Ave., New Orleans, La.

Rocky Mountain and Inland Empire

L. A. Mueller, Rocky Mountain Forest Exp. Sta., Ft. Collins, Colo.

E. S. Kotok, Intermountain Forest and Range Experiment Station, Ogden, Utah.

Pacific Area

R. D. Graham, Oregon Forest Product Lab., 17th & May Sts., Corvallis, Ore.

Liaison-Association and Other Activitie (AWPA, ASTM, etc.)

J. N. Roche, Tar Products Div., Koppers Company, Inc., 1200 Koppers Bldg Pittsburgh 19, Pa.

Wood Products Preservation (Low Density Board, Hardboard, etc.)

G. G. Marra, Div. of Industrial Researcl Wash. State Institute of Techn., Pullmar Wash.

FPRS News-Digest, Continued

New Binder for Particle Board

A high-solids urea formaldehyde resin has been added to the line of Perkins Glues for wood bonding. Perkins B–65, reported to be a high quality binder resin, is intended for use in the manufacture of particle board by any standard process. Further information may be obtained from the Perkins Glue Co., Lansdale, Pa., or Kitchener, Ontario.

Shaper Head Bulletin

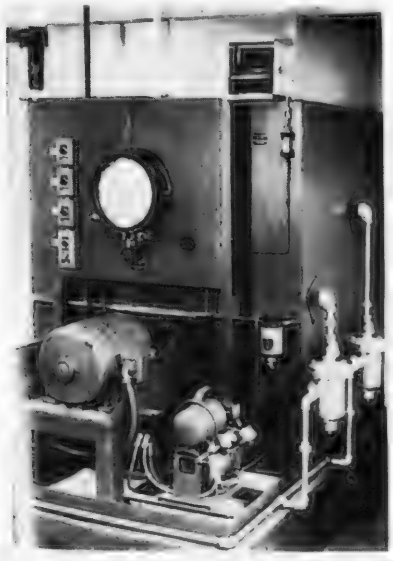
A two-color bulletin describing its line of shaper steel heads and knives is available from Wisconsin Knife Works, Box 309, Beloit, Wis. Bulletin 800 is illustrated with actual installation photos, as well as photos of the various types of shaper heads, collars, and knives available. It includes a complete list of both ball bearing and solid shaper collars and shaper steel, as well as carbide-tipped shaper knives. Various sizes that are carried in stock are indicated and a complete dimension of recommended sizes is given.

Lumber Drying Unit

Orr & Sembower, Inc., Reading, Pa., has entered into an agreement with Lumber Dryalators, Inc., Boston, to manufacture and sell a self-contained lumber drying unit called the Dryalator on an exclusive world-wide basis, it was announced recently by President F. H. Klein.

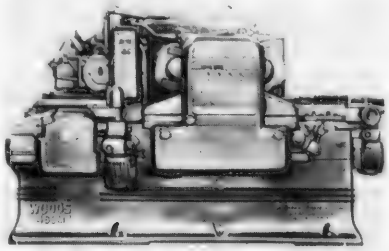
The firm will produce the Dryalator in its existing Reading plant facilities. It will be marketed through approximately 50 sales representatives throughout the country who now distribute the firm's Powermaster packaged automatic boilers.

The Dryalator, a packaged unit, is delivered completely assembled, ready to hook up to required services. It will be tested operationally as a single unit, hydrostatically and electrically, prior to shipment.



New Series of Blankers

The S. A. Woods Co., Boston, Mass., has developed a blanking machine which reportedly substantially reduces split lumber which occurs from running cupped and warped lumber through a planer. The 469 Blanker, placed between the feed table and matcher, presurfaces the board before entering the matcher, thereby eliminating the split lumber losses formerly caused by roll and chip-breaker pressures on the board. The manufacturer reports that this operation results in greater production through avoiding degrading losses by the mill.



The 469M Blanker has built in jointer bar for top and bottom cylinders. Knives may be changed without disassembling motor by means of a bottom head cylinder which can be pulled out. All operating adjustments can be made from the front or working side of the machine. The machine, which has sectional beveled top feed rolls bearing on top near the edges of cupped lumber, is powered by 3 motors of 30, 75, and 100 horsepower. The firm also produces blankers with the same features for use where less production is required.

Chipboard Production News

August, 1956 marked the first issue of the "Bartrev News" which contains latest developments in the field of chipboard production, particularly as applied to the Bartrev Continuous Press. Anyone may receive the "Bartrev News" by writing the Editor, 3 Vere Street, London, W. I., England.

Marketing Particle Board

National Starch Products Inc. will market particle board manufactured by Granite Board, Inc., Goffstown, N. H., according to officials of both companies. National Starch will act in cooperation with present distributors of Granite Board.

Granite board will be marketed by National's Structural Adhesives Division, which has a complete sales, technical service, and laboratory development staff serving the needs of the furniture industry. This division, with headquarters at 270 Madison Ave., New York, N. Y., presently markets vinyl resin glues for various high speed joining and laminating operations throughout the U. S.

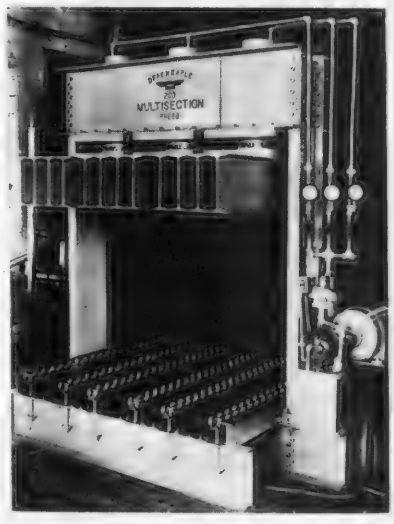
Insecticide Sprayer

Automatic clutch action has improved the pest-control equipment manufactured by the Silver Creek Precision Corp., Silver Creek, N. Y., the manufacturer reports. The automatic clutch permits smoother power transmission from the motor to insecticide-dispensing mechanism. Designed by Mercury Clutch Division of Automatic Steel Products, Inc., Canton, Ohio, the clutch permits the operator to start the motor and reach desired speed before engaging the dispensing equipment.

Company officials report that the use of the clutch affords more effective diffusion of insecticides, with resulting cost savings. The machine is a combination fogger-mister-duster-sprayer, designed for agricultural, municipal and industrial applications.

Multisection Presses

A line of Dependable Multisection Presses designed for assembly gluing in volume production by the cold glue, quick setting process is described in Bulletin C–25, available from Dependable Machine Co., Box 839, Greensboro, N. C. The presses have a wide range of uses, such as manufacturing high pressure laminates, television panels, hardboard, veneer, hollow core, kitchen cabinet doors and post building. The presses are being distributed by National Adhesives Division of



FPRS News-Digest, Continued

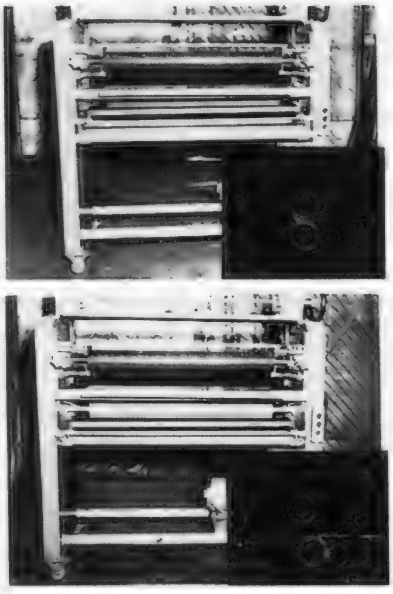
National Starch Products Co., 270 Madison Ave., New York 16, N. Y.

Built with a 42-inch vertical opening, the presses have a 12-inch stroke and are built for a unit pressure of 100 psi over the entire platen area, based on 3000 psi hydraulic pressure. Platen sizes range from 20 x 40 to 40 x 60.

Made of extra heavy construction, the presses have U beams for base construction, vertical supports, and top platen support. The heavy steel beams are rigidly bolted together to be able to withstand the high pressures possible. The bottom platen is constructed of wide flange beams which reportedly give unusual strength and rigidity.

Roller Coater Safety Device

A safety feature designed to eliminate hand and arm injuries to roller coater operators has been developed by the Union Tool Corp., 902 N. Detroit St., Warsaw, Ind. The safety feature consists of a release handle that runs the full width of the roller coater and is located immediately in front of the operator (upper view in photo). The safety release handle operates a latch pin which instantaneously releases the



complete lower roll assembly (lower view) including rolls, infeed table, pick-off fingers, and supply pan. (Inset drawings depict actual operation of the safety feature).

To reset the lower roll assembly, the operator uses a wrench to turn a cam bar, located on the operator side of the machine, until the bar brings the assembly to a fixed stop. At this point a spring-loaded latch pin engages, locking the assembly in operating position.

The manufacturer reports that this is the first such feature ever offered on machines of this type. It has been incorporated as standard on all heavy-duty models of Union roller coaters.

Abuse-Resistant Doors

An interior door that will reportedly resist prolonged abuse in public buildings has been developed by the U. S Plywood Corp., 55 West 44th St. New York, N. Y. The Weldwood Custom Royal Door is said to be sturdy, not easily damaged or marred and requires little maintenance, making it useful in hotels, restaurants hospitals, schools, and churches.

Surfaced with Micarta, a plastic covering, the door is claimed to be virtually immune to stains, won't chip splinter or corrode, and is restored to freshness with the sweep of a damp cloth. Micarta is made of resin-saturated layers of kraft paper on wood, fused under heat and pressure, and was previously widely used for bar and table tops.

Because of this surface, the manufacturer reports that the doors do not

For Continuous

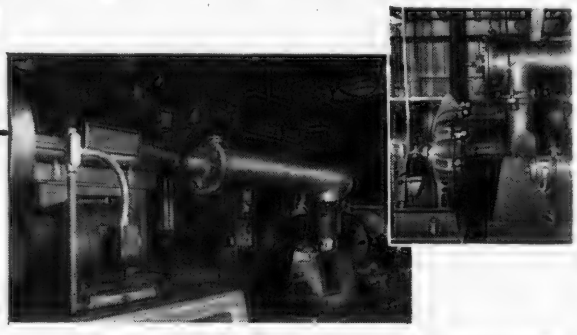
Pulping

THE ASPLUND DEFIBRATOR

For continuous pulping of wood chips or other cellulose material for hard board, insulating board, roofing and flooring felts, and corrugating board.

In the Defibrator process, the chips are uniformly pressure-cooked as they are conveyed through the digester tube where time, temperature, and pressure are controlled. Chips are then easily defibrated and passed through a blow valve to a cyclone where pulp is pumped to secondary refining or to a stock chest.

Yield is high, and power, operating, and maintenance costs are low. Capacity from 50 to 250 tons per day b.d. New 42" Defibrator now available.

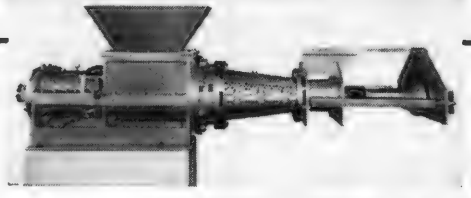


Dewatering

THE DEFIBRATOR BARK PRESS

Developed for continuous dewatering of bark for use as fuel. The Defibrator screw feed principle is used to reduce the moisture content of wet bark to 55% or below. In this state, bark burns readily with about half the fuel value of coal.

In installations now in operation, the processing capacity is approximately 5 tons per hour (on a b.d. basis) and power consumption at this capacity runs between 45 and 50 H.P. Heavy duty construction throughout. Specifications and detailed information on request.

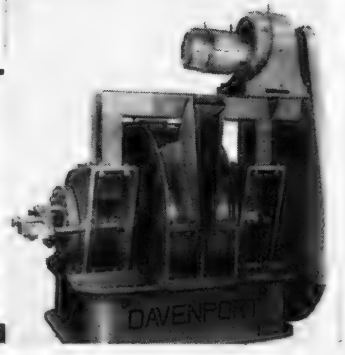


Extraction

THE DAVENPORT CONTINUOUS PRESS

For extraction of excess moisture from semi-solid materials—especially efficient for dewatering pulp and other fibrous materials, where fibers act as a filtering medium, aiding the screen plates in preventing loss of fines in the liquid which is forced out.

As these presses are continuous, they require little attention from the operator except for starting and stopping, with considerable saving in manpower. The process is completely mechanical, with low power consumption and high capacity. And because of its extremely rugged construction, maintenance costs are exceptionally low.

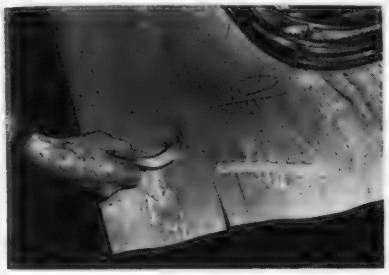


AMERICAN DEFIBRATOR, INC. CHRYSLER BUILDING NEW YORK 17, N. Y. West Coast: A. H. Lundberg Orpheum Building, Seattle, Wash.

require push-plates or kick-plates, need no waxing or staining, and offer no problem in removing fingerprints, dust or grease. It comes in four finishes, facsimiles of the graining of mahogany, oak, maple, and walnut, or may be obtained in decorator colors.

Plywood Patching Tape

A strong paper tape which has proved effective in patching veneers on fir plywood is announced by the Behr–Manning Co., Troy, N. Y. Developed to overcome the problem of veneer patches popping out in handling, the tape is reported to virtually eliminate rejects and save time.



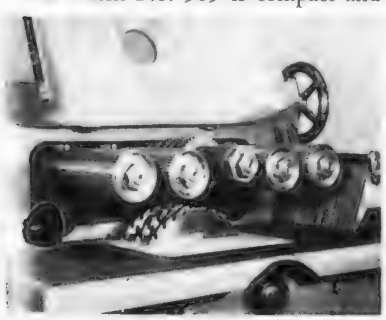
The photo illustrates No. 131 Rope Flatback pressure-sensitive paper tape being applied at the patching machine to hold the patch securely in place. After the panel has been sealed in the hot press, sanding will remove all trace of the tape. Although its adhesion averages 65 oz. per inch of width, the manufacturer reports that the tape is readily removed by sanding, without balling or gumming.

The tape, made from rope stock possessing tensile strength averaging 45 lb. per inch of width, is used in ¾ inch width on split or cracked veneer sheets to pull the split together during hot-press sealing. In plants with automatic loaders, splits may be taped at the press, rather than at the patching machine.

High Speed Rip Saw

A multi-rip saw which will reportedly rip stock from ⅛ to 2½ inches thick and from 5 inches to infinite length has been developed by G. M. Diehl Machine Works, Inc., Wabash, Ind. It has four feed speeds from 50 to 115 fpm.

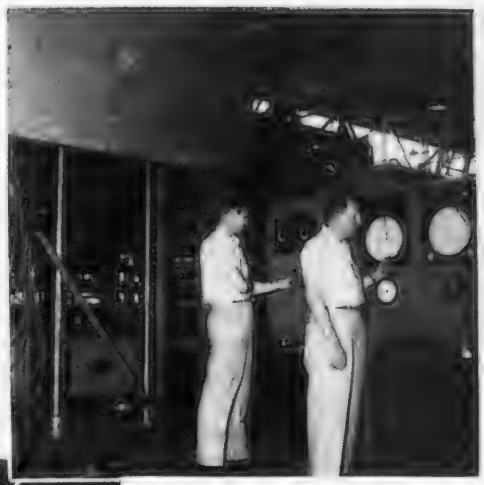
The Diehl No. 909 is compact and



WASHINGTON press "package" automatically handles pressing stage operation at Poinsett

PRESS

Key unit in the pressing stage of particle board manufacture at Poinsett Lumber Co., Pickens, S. C. is this 8-opening Washington hot plate press. The press, along with loading and unloading equipment, was designed and built by Washington Iron Works for Miller–Hofft Inc., designers of the new plant, to provide a completely automatic pressing stage operation, integrally engineered for fast, reliable production.



LOADER

The elevator-type loader and injector automatically handle and load the cauls into the press without manual operation.

UNLOADER

The ejector and elevator-type unloader complete the pressing stage equipment, automatically removing the finished board from the press.

The Poinsett Lumber Co. is the most recent of many hardboard, particle board and plywood mills using the Washington press "package" . . . loader, injector, press, ejector and unloader . . . for better quality and faster production.

Washington Iron Works,
1500 Sixth So., Seattle 4, Wash.

WASHINGTON IRON WORKS

Since-1882

WASHINGTON IRON WORKS

FPRS News-Digest, Continued

rigidly constructed, with arbor and arbor motor mounted on the frame. It has a reinforced table adjustable to a 4-inch maximum and permits cutting of throat plates in operative position, the manufacturer reports.

Illustrated is the hinged power feed roll cover on the multi-rip saw, exposing the power feed rolls, power spur feed, saw gang and idler rolls.

Dry Process Board

Production is scheduled to start in November on a new dry process board to be manufactured by Columbia Hardbord Co., Everett, Wash. The process and design for the high flexule strength (mor) three-layer flake panel was developed by Industrial Development Co., Inc., Tacoma.

The design provides for manufacture of a panel smooth on both sides in thicknesses from 3/8 to 1 1/4 inches. Produced from cedar waste, the product will be marketed under the name Cedawood.

Designed an an underlayment for hardwood veneer and plastic laminates, the new panel will have the following minimum specifications: density, 40 lbs. per cubic foot; mor minimum, 3800; screw holding, face, 350 lbs. minimum; screw holding, edge, 250 lbs. minimum; water absorption, 24 hour soak, 12%; thickness swell, 24 hour soak, 6%.

Other reported properties of Cedawood include: good nail holding close to edges, easily sanded or machined.

NEW PUBLICATIONS

Ohio's Forests and Wood-Using Industries. O. K. Hutchison and J. T. Morgan. Forest Survey Release 19, Central States Experiment Station, Columbus, Ohio.

Iowa Forest Statistics. Forest Survey Release 20, Central States Forest Experiment Station, Columbus Ohio.

New Grading and Bundling Specifications for Western Red Cedar Siding. Illustrates characteristics of each of the four new red cedar grades with photographs. Western Red Cedar Lumber Assn., 4403 White-Henry–Stuart Bldg., Seattle 1, Wash.

Selecting Lumber. C. S. Walters. Contains facts about lumber and its use in home building, and discusses how grain, defects, and moisture content affect the quality and strength of wood. Small Homes Council, University of Illinois, Urbana. 10 cents per copy.

Seasoning Hickory Lumber and Handle Blanks. J. M. McMillen, U. S. Forest Products Lab. Hickory Task Force Report No. 4, published by Southeastern Forest Experiment Station, Asheville, N. C.

Research Work of the Forestry Branch. Misc. Pub. No. 6, Depart-

PROFESSIONAL CARDS

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INDUSTRIAL PLANT ENGINEER
Specialist in
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Design, Supervision of Construction
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Loyalty Bldg. Portland 4, Ore.

NEWMAN K-16 Tilting Arbor VARIETY SAW

Rips to 48" wide

DESIGNED for YOUR PROFIT

Micrometer double faced rip fence with rack and pinion adjustment permanently aligns fence with saw blade and allows cuts to full 48" wide. Handwheel locks both sides of fence simultaneously. Guard and splitter automatically tilt with saw blade. Guard has anti kickback fingers. All cast iron base and table. Direct connected 3600 R. P. M. 5 H. P. motor. Full 45° tilt of saw with positive lock for holding tilt. Delivery from stock subject to prior sale. Write for descriptive literature and complete quotation.

NEWMAN MACHINE COMPANY, INC.
GREENSBORO, NORTH CAROLINA, U. S. A.

For a *truly* good floor

NORTHERN HARD MAPLE

truly economical

truly modern

truly resilient

★

MAPLE FLOORING MANUFACTURERS ASSN.
CHICAGO 1, ILLINOIS

ment of Northern Affairs and National Resources, Ottawa.

Decay and Discolourations in Poplar Pulpwood. E. A. Atwell. Forest Products Laboratories of Canada, Ottawa.

Quality Control and Applied Statistics Abstracts. Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y. $60 per volume. Monthly looseleaf abstract service will consist of one volume of about 1,000 pages yearly. World literature on quality control, operations research, and industrial applications of statistical methods will be abstracted.

Wood Structural Design Data. (Revised). Contains basic information needed by the building industry to design with lumber for structural purposes. $4 per copy, National Lumber Manufacturers Association, Washington 6, D. C. Copies of National Design Specifications available at 50 cents each.

How to Measure Wood in Moving Conveyors. R. G. Belcher and W. H. Martin. Equipment Handbook Release No. 266, American Pulpwood Association, 220 E. 42nd St., New York 17, N. Y. Reprint from Paper Trade Journal.

The following publications are available without charge from the U. S. Forest Products Laboratory, Madison, Wis.

List of Publications on Box and Crate Construction and Packaging Data. No. 791

Partial List of Publications for Furniture Manufacturers, Woodworkers, and Teachers of Wood Shop Practice. No. 1775

List of Publications on Chemistry of Wood and Derived Products. Report 238. Contains titles of 450 articles and publications on the chemical composition of wood, chemical and physical properties, and the chemical processing of wood.

List of Publications on Logging, Milling, and Utilization of Timber Products. Report No. 790.

Simplified Procedure for Developing Grade Lumber from Hardwood Logs. F. B. Malcolm. Report No. 2056. Describes and illustrates techniques for minimizing defects; sawing logs with taper, seam, sweep, and rot; and edging and trimming lumber for the highest possible grade.

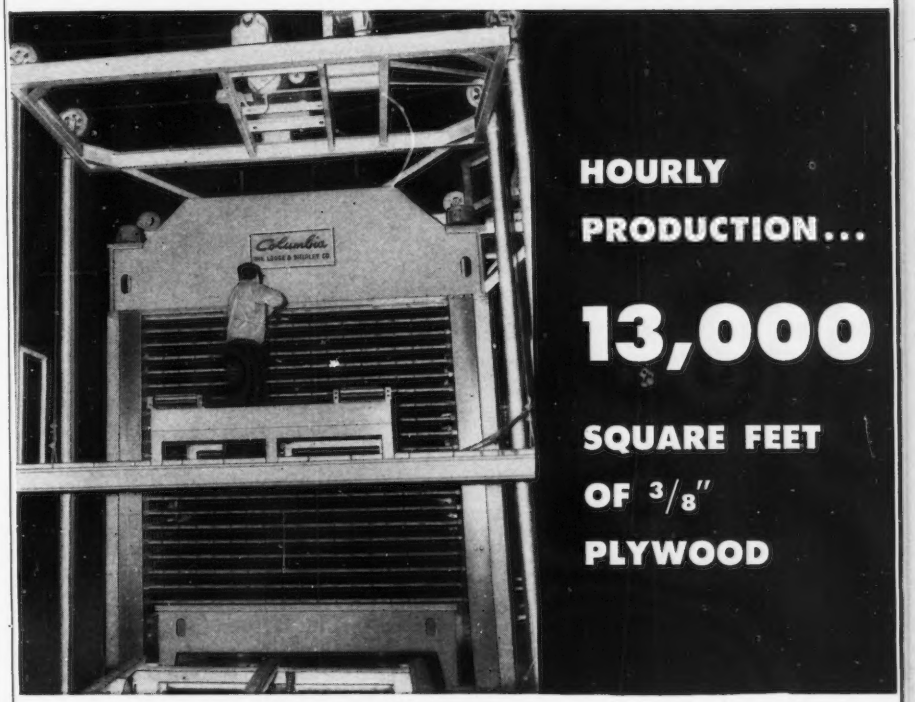
Changes in Spiral Grain Direction in Ponderosa Pine. B. H. Paul. Report 2058.

Manufacture and General Characteristics of Flat Plywood. No. 543, Revised. Discusses the selection of veneer, lumber, and adhesives, gluing and pressing operations; conditioning, finishing, trimming, and sanding; and shrinkage, warping, and face checking of various types and grades of plywood.

Condition of Preservative Treated Field Boxes after 5 Years of Outdoor Exposure. R. S. Kurtenacker, T. C. Scheffer, and J. O. Blew. Report 2054. Evaluates the effectiveness of preservative treatments for wood boxes used in the field, determines the value of water-repellent preservatives as agents for stabilizing the weight of containers, and determines whether water-repellent treatment reduces damage caused by swelling and shrinking that result from changes in moisture content.

Ladders and Ladder Safety. L. J. Markwardt. Reprint from Plant Engineering, 1956.

Thermal Degradation of Wood and Cellulose. A. J. Stamm. Estimates are made of the degradation of wood under kiln drying conditions and of the weight and strength losses of dry wood and the strength loss of dry paper on prolonged storage at room temperature. Reprint from Industrial and Engineering Chemistry.



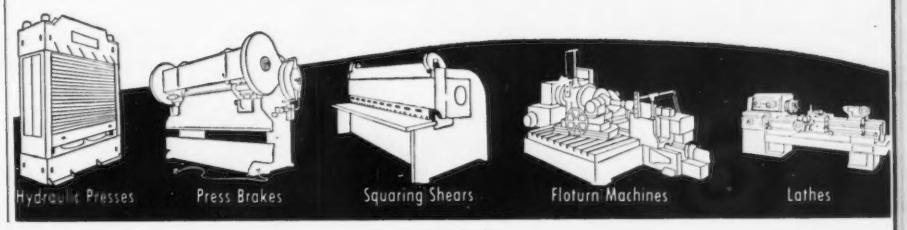
WITH THIS LODGE & SHIPLEY

Columbia HOT PLATE PRESS

It takes smooth, trouble-free operation to roll up a 13,000 feet per hour production record and maintain it through days and weeks of operation . . . as reported by the Plywood Division, Diamond Lumber Co., Portland, Oregon.

Easy-rolling production is a characteristic of Columbia Hydraulic Hot Plate Presses built by Lodge & Shipley. Widely accepted by leading producers of wood, plastic and laminated products, these Columbia Presses have 15 outstanding features for increased output and quality.

For complete details, request Bulletin HP-11 from: The Lodge & Shipley Co. 3063 Colerain Ave., Cincinnati 25, Ohio



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Buss Machine Works	13–A
Carr, Adams & Collier Co.	101–A
Cascades Plywood Corp.	70–A
Catalin Corporation of America	44–A
E. L. Cederquist Co.	49–A
Chapman Chemical Co.	3–A
CKL Machinery Co.	90–A
Coe Manufacturing Co.	79–A
Columbia Hardbord Co.	21–A
Columbia–Hudson Lumber Co.	90–A
Consolidated Baling Machine Co.	105–A
Delmhorst Instrument Co.	50–A
G. M. Diehl Machine Works, Inc.	19–A
Durez Plastics Division, Hooker Electrochemical Co.	16–A
Ekstrom, Carlson Co.	42–A
Enterprise Company	71–A
Fastener Corp	102–A
Filer & Stowell Co.	17–A
Gamble Brothers, Inc.	105–A
Greenlee Bros. & Co.	4–A
Hotel Hamilton	96–A
Hammond Lumber Co.	93–A
Handy Manufacturing Co.	78–A
Harshaw Chemical Co.	86–A
Hawker Manufacturing Co.	94–A
Hyster Company	89–A
Independent Nail and Packing Co.	99–A
Kennametal, Inc.	30–A
Ketchikan Spruce Mills	87–A
Kirk & Blum Manufacturing Co.	81–A
Koppers Co., Inc.—Chemical Division	12–A
Koppers Co., Inc.—Wood Preserving Division	103–A
Laucks Laboratories, Inc.	87–A
Lilly Varnish Company	95 A
Lodge & Shipley Co.	111–A
C. M. Lovsted & Co.	68–A
Mann–Russell Electronics	18–A
Maple Flooring Manufacturers Association	110–A
Masonite Corp.	29–A
Mater Engineering	110–A
Mattison Machine Works	3rd Cover
Mereen–Johnson Machine Co.	28–A
Miller Hofft, Inc.	105–A
Moisture Register Co.	25 A
Monsanto Chemical Co.	10–A
Moore Dry Kiln Co.	85–A
Morton Salt Co.	27–A
D. J. Murray Manufacturing Co.	72–A
National Casein Co.	9–A
National Starch Products Co.	5–A
Newman Machine Co.	110–A
Nicholson Manufacturing Co.	46–A
Oliver Machinery Co.	70–A
Oasrud Machine Co.	92–A
Orr & Sembower, Inc.	23–A
Orton Machine Co.	50–A
Parkwood Laminates, Inc.	41–A
Perkins Glue Co.	4th Cover
Ply-Curves, Inc.	25–A
Power-Line Sales Co.	80–A
Proctor & Schwartz, Inc.	74–A
Protection Products Manufacturing Co.	24–A
Radio Receptor Co., Inc.	11–A
W. H. Rambo	110–A
Reichhold Chemicals, Inc.	2–A
Rockwell Manufacturing Co.	25–A
B. M. Root Co.	87–A
Saranac Machine Co.	104–A
Grant B. Shipley	112–A
G. Siempelkamp & Co.	83–A
Simpson Logging Co.	101–A
Soderhamn Machine Manufacturing Co.	88–A
Solem Machine Co.	14–A
Spotnails, Inc.	84–A
Standard Dry Kiln Co.	50–A
Sta-Warm Electric Co.	100–A
Stetson-Ross Machine Co., Inc.	22–A
Synco Resins, Inc.	31–A
Timber Engineering Co.	64–A
United Shoe Machinery Co.	91–A
U. S. Plywood Corporation	67–A
Universal Door Carrier, Inc.	93–A
Wabash Screen Door Co.	48–A
Walters Manufacturing Co.	32–A
Washington Iron Works	109–A
Paul Watts, Inc.	112–A
Weyerhaeuser Timber Co.	52–A
Whitmire Research Laboratories, Inc.	96–A
A. W. Williams Inspection Co.	112–A
Williams Patent Crusher & Pulverizer Co,	69–A
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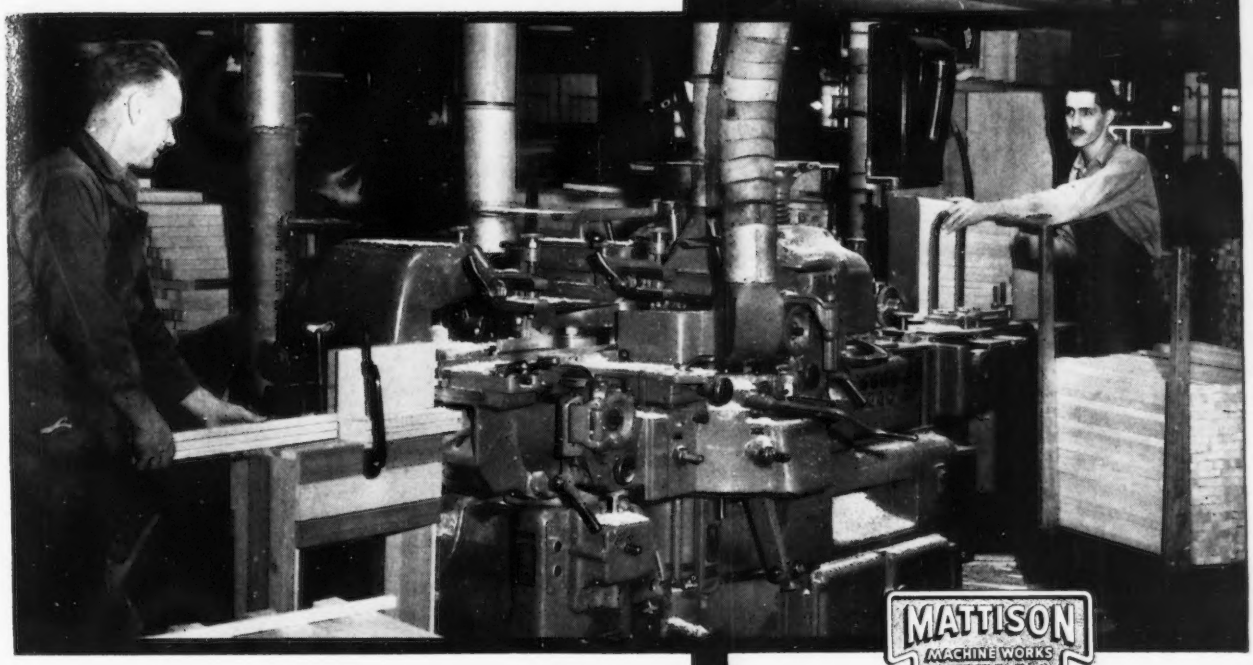
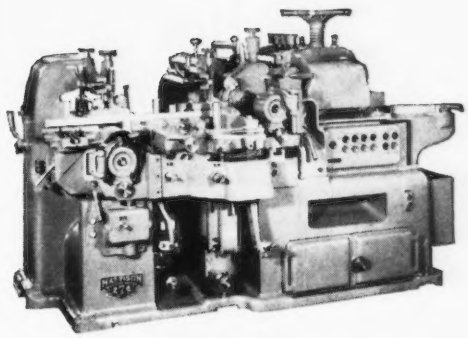


Everett Piano Company, South Haven, Mich., names several profitable and worth-while features of the Mattison No. 276 Moulder. They find the machine exceptionally easy to set up because of the accessibility of the cutterheads. The wide range of feed speeds on the machine have been instrumental in reducing their sticker costs. Another feature they find profitable is the automatic feeding device which is particularly useful in working up short stock. Automatic feed reduces idle cutting time of the cutterheads, increases capacity of the machine, and reduces machining costs.

The Mattison Moulder is a close-coupled, rigid machine which features vibration-free operation for the production of delicate mouldings, but has the reserve power and stamina for larger mouldings, too.



Mattison No. 276 Moulder

Available in 4 and 6 in. sizes, these machines feature precision, vibration-free operation for delicate moulding, as well as the power and ruggedness for larger mouldings. Close-coupled, high-speed design provides low-cost high-capacity production.

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Rockford, Illinois

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